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United Packing: Alcohol Feasibility Study

Brown and Caldwell
Walnut Creek, CA

Prepared for

California State Solid Waste Management Board
Sacramento

Oct 81

U.S. Department of Commerce
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PB82-178476

UNITED PACKING

FINAL REPORT
ALCOHOL FEASIBILITY STUDY

STATE SOLID WASTE
MANAGEMENT BOARD

OCTOBER 1981

BROWN AND
CALDWELL

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The disposal of cull fruit coming from packing sheds is a large but seasonal solid waste management problem in the Central Valley. Present disposal practices include landfilling, land spreading, and use as animal feed. Typically, these methods represent an economic liability to the packers in addition to being a waste of potential resources. Cull fruit contains significant amounts of sugar which can be converted into ethanol using current technology. The ethanol has several uses, one of which is a fuel to provide on-site energy for plant processing needs. This report was intended to evaluate the potential for ethanol production from cull fruit at United Packing's Sanger plant. However, ethanol production is only one part in an overall energy management plan for the plant. Cogeneration and other power production options utilizing ethanol, to provide both total and partial energy independence from utilities are also examined. Information from the alcohol production evaluation, energy survey, biomass profile, and power production analysis is integrated in the final,...

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OCTOBER 1981

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CHAPTER 1

INTRODUCTION

The disposal of cull fruit coming from packing sheds is a large but seasonal solid waste management problem in the Central Valley. Present disposal practices include landfilling, land spreading, and use as animal feed. Typically, these methods represent an economic liability to the packers in addition to being a waste of potential resources.

Cull fruit contains significant amounts of sugar which can be converted into ethanol using current technology. The ethanol has several uses, one of which is a fuel to provide on-site energy for plant processing needs. This report was intended to evaluate the potential for ethanol production from cull fruit at United Packing's Sanger plant. The analysis indicated that production of about 60,900 gallons per year of 190-proof alcohol is possible with an accompanying reduction in the solid waste quantity to disposal of about 90 percent.

However, ethanol production is only one part in an overall energy management plan for the plant. Cogeneration and other power production options utilizing ethanol, to provide both total and partial energy independence from utilities are also examined. An on-site energy survey was performed to establish an energy use profile. The profile defines how much, when, and where energy is currently consumed at the plant. Energy conservation measures (ECMs) are identified which can reduce current energy consumption. An evaluation of agricultural residues in a four-county area around Sanger is also included. These residues can be used as fuels in several of the power production options.

Information from the alcohol production evaluation, energy survey, biomass profile, and power production analysis is integrated in the final chapter, and an overall energy management plan is defined.

CHAPTER 2

ENERGY ANALYSIS

This chapter examines the present energy usage at United Packing's Sanger plant and identifies a number of ways to reduce energy use. First, an energy model is developed to determine how much and where energy is currently used. This model identifies all components of energy use at the plant. The large components are then the focus of the energy conservation discussion. A group of feasible energy conservation measures (ECMs) are identified which can reduce energy costs by about $23,000 per year with a simple payback of less than 5 months. The ECMs are covered in detail in the later part of this chapter.

ENERGY USE MODEL

Utility bills and data gathered from an on-site visit are used to determine how much and where energy is used at the Sanger plant.

Annual Energy Use

Examination of electric utility bills for a 12-month study period, April 1980 through March 1981, indicates that energy costs were about $179,000 and the facility consumed some 2.9 million kilowatt-hour (kwhr). If the facility uses a comparable amount of electricity in the next 12 months and energy costs increase by an estimated 35 percent, energy costs will total approximately $240,000.

In the following discussion, it is important to understand there is a distinction between energy use and demand. Energy use is the total kwhr actually consumed, while demand is the peak power required in any month. This distinction is important because United Packing is billed, at different rates, for energy use kwhr and demand kilowatt (kw).

Figure 2-1 shows annual electricity use and demand for the study period on a monthly basis. Notice that the majority of electricity is used during the period May through November. This period accounts for about 88 percent of the annual use. In July, the peak use month, the facility used about 546,300 kwhr, while in February, the lowest use month, the facility used about 50,100 kwhr. Monthly electricity demand follows a similar pattern. The peak monthly demand occurs in July at 1,475 kw. The lowest demand of 203 kw occurs in February.

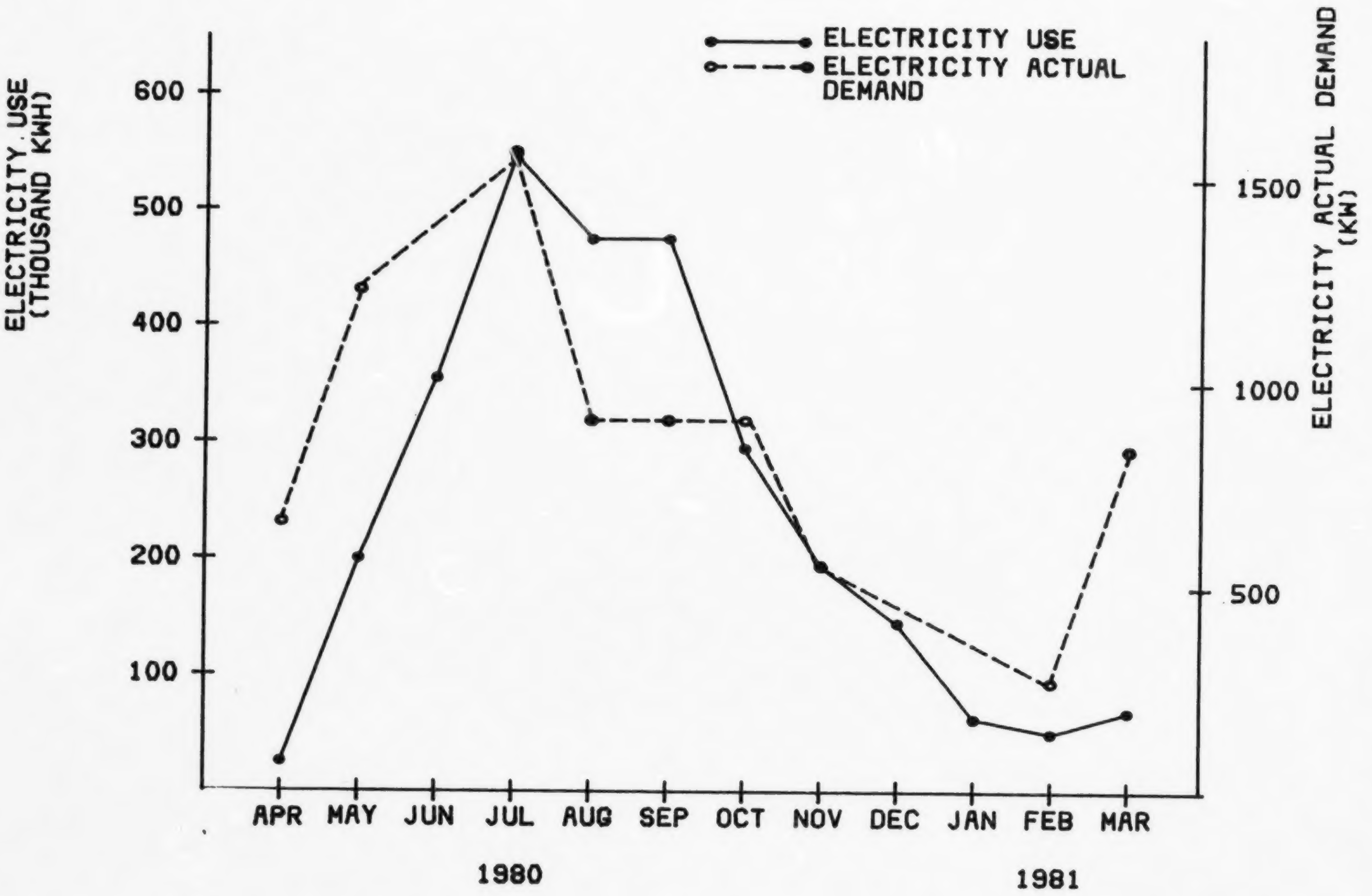

Figure 2-1 Monthly Electricity Use and Demand

Daily Energy Use

Hourly electrical measurements were made during the site visit on June 25, 1981. Measured ammonia refrigeration machinery demand is shown on Figure 2-2. Compressors 3, 4, and 5 were measured separately, and their demand was totaled to give the solid curve. A base load of about 200 kw occurs at night for bin coolers and cold storage rooms. When the hydrocooler is started, total demand increased to about 740 kw, then drops back to the 610 to 645 kw range until the hydrocooler is shut down at night.

Figure 2-3 shows estimated electrical demand for a typical summer day with the hydrocooler in operation. The base load, not including refrigeration compressors, is about 254 kw. This includes evaporator and circulation fans, refrigeration fans and condensers, packing area evaporative coolers, and office air conditioners. Some of the refrigeration capacity is required during the night to provide cooling for the bin coolers and cold storage rooms. This increases the night base load to about 453 kw.

When the hydrocooler starts, the load peaks at about 1,375 kw, then settles back to about 1,242 kw during the work day. Included in this daytime peak are the electric motors to drive the sorting and packing lines, hydrocooler pumps and conveyor drive, lights in packing area and offices, and additional ammonia compressors to run the hydrocooler and the air compressor. Table 2-1 summarizes these components for both night and day.

Energy Use Components

An estimate of the components of annual electricity use for the study period is shown in Table 2-2. Notice that process cooling (cooling room evaporator fans, ammonia refrigeration compressors and oil pumps, and refrigeration fans and compressors) represents the largest portion of electricity use, about 74.6 percent of the annual total. Sorting and packing lines consume about 8.1 percent of the total. Lights consume about 7.8 percent. The remainder of electricity uses are individually a much smaller portion of the total. Components include packing room evaporative coolers, office air conditioning, the air compressor, and miscellaneous other uses. Table 2-3 identifies annual electricity use on the packing lines by fruit type.

ENERGY CONSERVATION MEASURES

Based on the energy audit, interviews with management and operations staff, examination of the monthly electricity bills, and the energy use model, several cost-effective ECMs have been

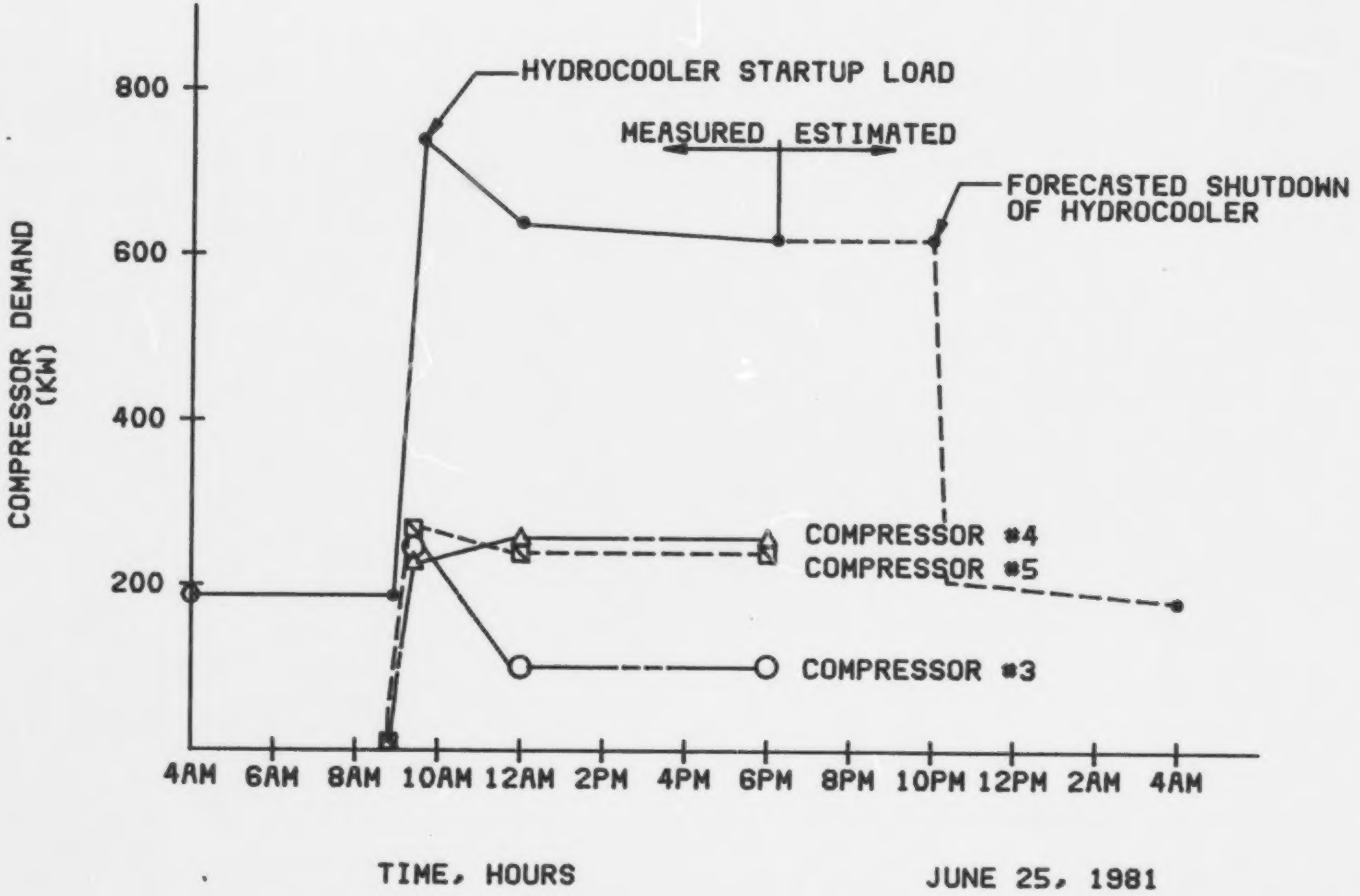

Figure 2-2 Measure Compressor Electrical Demand for Refrigeration

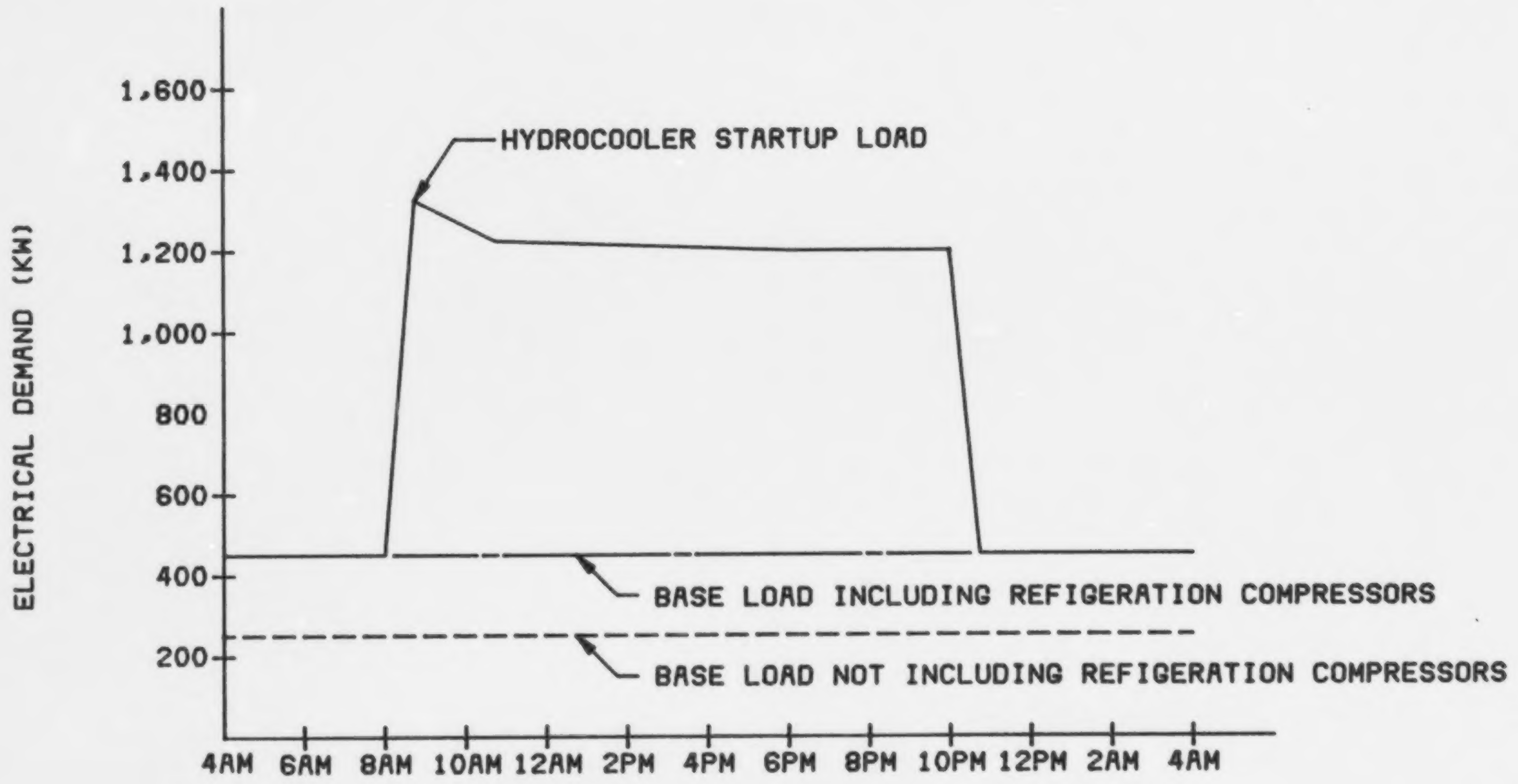

Figure 2-3 Typical Summer Day Electricity Demand With Hydrocooler in Operation

Table 2-1 Night and Day Electrical Demand Components

Component	Demand, kw
Night	
Refrigeration compressor	198.6
Evaporator and circulation fans	137.0
Refrigeration fans, condensers	62.3
Packing area evaporative coolers	35.1
Office air conditioning	16.0
Lights	4.0
Total night	453.0
Day	
Total night components	453.0
Refrigeration compressors (average)	421.4
Production lines	167.5
Hydrocooler pumps and conveyor	92.6
Packing area and office lights	77.0
Air compressor	30.6
Total day	1,242.1

Table 2-2 Components of Energy Use

Component	Annual use, thousand kwhr	Percent of total
Refrigerant compressors and oil pumps	1,596.1	55.0
Cooling room evaporator fans	412.0	14.2
Refrigeration fans and condensors	54.8	1.9
Sorting and packing lines[a]	236.7	8.1
Lights	227.6	7.8
Packing room evaporative coolers	140.8	4.8
Office air conditioners	95.0	3.3
Hydrocooler pumps and conveyor drive	76.4	2.6
Air compressor	13.4	0.5
Miscellaneous	52.2	1.8
Total	2,905.0	100.0

[a] See Table 2-3 for breakdown.

Table 2-3 Packing Line Energy Use by Fruit Type

Fruit type	Annual use, thousand kwhr
Apricot/plums	87.7
Peaches	77.8
Nectarines	54.2
Grapes	13.7
Kiwis	3.3
Total	236.7

Table 2-4 Summary of Recommended Energy Conservation Measures

Description	Cost to implement, dollars[a]	Annual energy cost savings, dollars[b]	Payback period
Shut off evaporator coolers nights/ weekends	2,390	5,760	5[c]
Shut off cooling to palletizing area and loading docks nights/weekends	1,430	4,990	3[c]
Shut off office AC nights/weekends	1,380	5,190	3[c]
Start hydrocooler sooner each packing day	-	1,510	-
Reduce hydrocooler cooling losses			
Add flexible seals to entrance/exit	2,000	5,070	5[c]
Add wall insulation	850	410	2.1[d]
Add sump insulation	400	140	2.9[d]
Add top insulation	800	260	3.1[d]
Consolidate fruit in bin coolers and cold storage rooms	0	-[e]	-
Shutoff unused compressed air lines	0	-[e]	-
Improve electric motor power factor and efficiency	-	-[e]	-

[a] This includes cost of energy management system programmable controller ($2,500) and remote switches ($300 each) installed. Programmable controller cost has been distributed among all measures in proportion to energy cost savings.

[b] At current utility rates. See Table 2-5.

[c] Months.

[d] Years.

[e] Unknown.

identified. All recommended ECMs are summarized in Table 2-4. Each has attractive economics, whether considered separately or as a group. If implemented as a group, they will reduce energy costs by about 12.7 percent, or about $23,330 (368,000 kwhr) annually, at current Pacific Gas and Electric Company (PGandE) rates. The estimated initial cost of these measures totals about $9,250, giving a simple payback period of less than 5 months. The economics will look even more attractive after taxes and investment and energy conservation incentives are taken into account. The recommended ECMs can be implemented without disruption to the fruit packing process or to building occupants. Measures involving modifications to the hydrocooler can be implemented during the winter months while it is not in service. The effect on the monthly energy consumption of implementing all the ECMs listed in Table 2-4 is presented in Table 2-5.

A number of additional ECMs have been identified that are not cost-effective now. However, as utility rates increase, some of them warrant further consideration.

Current PGandE rates used for this analysis are shown in Table 2-6. These rates went into effect June 21, 1981.

Reduce Equipment Operating Hours

At present, several types of equipment run continuously during the packing season that could be shut down nights and weekends. This function could be performed with a simple energy management system such as the National Energy Solution 100. This system transmits coded digital signals from a central programmable controller to remote switches, and each switch will accept up to 83 programs. (A program is an "on," "off," or "duty cycle" command.) Using this type of system, operating staff can readily control the hours of operation for the following equipment (see the appendix for a cut sheet describing the National Energy Solution 100 equipment).

Packing Area Evaporative Coolers. Currently, these coolers run most nights and weekends during the packing season. If they were turned off 12 hours per day, Monday through Friday, and from Saturday noon until 8:00 a.m. Monday, from April through September, electrical use would be reduced by an estimated 101,000 kwhr, or $5,760 annually. The central controller could be programmed to start evaporative coolers 30 minutes before occupancy each day to bring temperatures to acceptable levels when people begin work. Controllers could also be programmed to run some coolers all night when onions are stored in the packing area.

Palletizing Area, Loading Hallway, and Loading Docks. If cooling fans for these areas were turned off for the same periods as for the evaporative coolers, electrical use would be reduced by an estimated 94,800 kwhr, or $5,400 annually.

Table 2-5 Current and Projected Energy Use

Month	Energy use, thousand kWh	
	Present (1980)	Projected
April	22,200	17,700
May	201,900	139,900
June	357,900	275,500
July	546,300	466,300
August	480,600	413,100
September	480,600	413,100
October	296,100	291,400
November	193,800	193,800
December	144,300	144,300
January	64,500	64,500
February	50,100	50,100
March	66,900	66,900
Total	2,905,200	2,536,600

Table 2-6 PGandE Rate Schedule No. A-12 (Effective June 21, 1981)

	Dollars
Demand charge, per meter per month	
First 40 kw of billing demand or less	91.00
Next 260 kw of billing demand, per kw	1.99
Over 300 kw of billing demand, per kw	1.82
Energy charge	
All kwhr, per kwhr	.01761
Adjustments, per kwhr	
Energy cost adjustment	.039268
Tax change adjustment	.00004
Total adjustments	.039308
Total energy charge, per kwhr	.056918

Office Air Conditioners. If office air conditioners were turned off 12 hours per day, Monday through Friday, and from noon Saturday until 8:00 a.m. Monday, April through September, and from 5:00 p.m. to 8:00 a.m., Monday through Friday, and all weekends during the rest of the year, electrical use would be reduced by an estimated 89,400 kwhr, or $5,090 annually.

The cost of the programmable controller capable of controlling all of the above equipment is about $2,500. The remote switches cost about $300 each, installed. The system could be expanded as desired to control another 80 to 90 points. In Table 2-4, the cost of the programmable controller has been distributed among all ECMs requiring its functions in proportion to the energy cost savings.

Improve Hydrocooler Efficiency

The hydrocooler, including the circulating pumps, conveyor drive, refrigeration of chiller water, and fans and condensers associated with refrigeration, consumes a large amount of electricity. It uses an estimated 553,400 kwhr annually, or about 19 percent of all electricity used by the facility. At today's utility rates, this amounts to about $37,500 annually, including energy and demand charges. For this reason, the hydrocooler has been examined closely for possible ECMs. Several feasible ECMs have been identified and are recommended for implementation.

Start Up Hydrocooler Earlier. Start the hydrocooler earlier to precool water in the sump over a longer time period to eliminate the start-up peak that currently occurs between 9:00 a.m. and 10:00 a.m. when the hydrocooler is in operation (see Figure 2-3). This would reduce peak power demand by about 150 kw and save about $1,650 annually in demand charges. It could be accomplished by running only one or two of the existing 25-horsepower circulating pumps rather than all four of them to cool water down to 33 degrees Fahrenheit (F). Running two pumps 1 hour more each day would only increase electricity use by about 2,480 kwhr, or $140 annually. Thus, the net cost savings would be about $1,510 annually.

Reduce Hydrocooler Cooling Losses. The hydrocooler is losing considerable amounts of cooling to the ambient air surrounding it. Estimates indicate that of its 400 ton cooling capacity, over 100 tons is lost to the surroundings by convection and radiation. Several ECMs are recommended to reduce these losses:

1. Install rubber or plastic strip door seals around entrance and exit to the hydrocooler. There is about 1 foot of horizontal clearance between the walls of the hydrocooler and the bins and about 3 to 4 feet of vertical clearance between the refrigeration coils and the tops of the bins. An estimated 100,000 tons of cooling is lost annually from air motion through the hydrocooler. If strip door seals

could reduce this loss by 80 percent, this would amount to a savings of about 74,000 kwhr annually, or $5,070 including energy and demand charge savings. The cost to install practical and effective door seals is estimated conservatively at $2,000.

2. Install wall insulation on concrete side walls. Insulation of 2-inch urethane boardstock would save about 6,015 kwhr annually, or $410 including energy and demand charges. Cost of materials and installation is estimated at $850.
3. Add an insulating cover to the sump along the side of the hydrocooler. A plywood cover over the sump with 2-inch urethane boardstock insulation would save about 2,080 kwhr annually, or about $140 including energy and demand charges. It would cost about $400, installed.
4. Add an insulating top cover above cooling water distribution trays. The proposed cover consists of 2-inch urethane boardstock insulation over plywood supported by angle iron spanning the 11-foot distance between hydrocooler side walls. Provision would have to be made to open or move the cover for weekly cleaning of water distribution trays. This cover would reduce electricity use by about 3,780 kwhr annually, or $260 including energy and demand charges. The estimated cost is $800.

Operations and Management Measures

Several other ECMs have been identified that will significantly reduce energy use. However, it is difficult to assess the magnitude of the savings at this time. They are described below.

Bin Coolers and Cold Storage Rooms. Manage these areas so that cooling is turned off as soon as a room is empty and consolidate fruit; that is, move fruit from nearly empty rooms to one still in use and turn off cooling in the empty rooms.

Compressed Air Distribution System. The compressed air distribution system was designed for the trailer manufacturing company that originally occupied the facility. Consequently, the distribution system is quite extensive and the entire system is still under pressure. Consider valving off lines that are not currently in use as there are probably some leaks in the system.

Electric Motor Improvements. The overall plant power factor could most likely be improved by the addition of capacitors to electric motors of over 5 horsepower. In addition, as motors fail, they should be replaced with high efficiency models or rewound with the Wanlass Technologies windings (see Appendix A for description).

Future ECMs

Several other ECMs were considered but are not recommended for retrofit at this time, either because they are not practical or are not economically feasible at current energy rates. They are described below.

Install Ice-Accumulator Refrigeration System. An ice-accumulation refrigeration system would make chilled water for the hydrocooler using refrigeration of moderate capacity to freeze ice on coils in a water tank. The system would operate 24 hours per day during periods of hydrocooler operation and make ice that melts off when the produce load is heavy. It would reduce refrigeration loads for hydrocooler operation by about 50 percent, or about 210 kw for a hydrocooler the size of the existing one. This would result in an annual demand charge savings of about $2,300. The savings does not warrant retrofitting the existing hydrocooler, but ice accmulation should be considered when hydrocooler capacity is expanded.

Precool Hydrocooler Sump Water Overnight. Install a 12,000-gallon insulated storage tank, circulation pump, and evaporator connected to the existing ammonia refrigeration system and install an additional heat exchanger to recover "cool" from the spent sump water as it is being discharged to the drain. This would eliminate the present start-up peak and eliminate running all four existing 25-horsepower circulating pumps in the hydrocooler during start-up. The energy cost savings is estimated at $2,500. The cost of a 12,000-gallon insulated storage tank alone would cost at least $15,000. This ECM is not economically feasible at current electricity rates but should be considered in the future.

Fully Immerse Fruit in Chilled Water Bath. This would reduce circulation pumping head and hydrocooler losses. In order to effectively chill the fruit, the water bath would have to be agitated or circulated through bins. This design would consume about half the energy for circulating pumps that is currently required, yielding an estimated savings of $2,600 annually and reduce the cooling losses substantially; they currently are about $6,300 annually. The cost to retrofit the existing hydrocooler would be many times the savings and cannot be justified. However, it is advisable to consider this design for the next hydrocooler before it is installed.

Reduced fruit retention time is an additional advantage to this scheme. In a hydrocooler test, a standard 4-foot by 4-foot bin of peaches was showered with a flow of 10 gallons per minute (gpm) per square foot of bin area. The peaches cooled in 24 minutes when the bin was filled with water and fruit immersed, but 30 minutes were required when no water filling occurred. Based on this test, retention time could be reduced by about 20 percent.

Control Evaporator Fan Operation. The evaporator fans in bin coolers, cold storage rooms, precoolers, palletizing area, and loading docks currently use about 412,000 kwhr annually at a cost of about $23,500. Because this is a large component of United Packing's energy use, we explored the possibility of reducing the hours of fan operation.

Two control strategies were considered. The first involves thermostatically controlling fans to only run long enough to satisfy the cooling load. As this might cause control problems, a second alternative was considered. It involves duty cycling the evaporator fans with a thermostatic override so that if fans are off and space temperature gets too high, the thermostat will turn the fans back on.

These control strategies were discussed with Ray Cliever of Industrial Cooling Equipment, the firm that designed the refrigeration plant. He indicated that cycling the fans would cause unacceptable swings in relative humidity, that the preferred relative humidity range is 94 to 95 percent, and that nothing below 90 percent is acceptable. Therefore, this ECM has not been pursued further. If it could be, the potential annual energy cost savings is estimated at $4,500.

New Drives on Screw Compressors

Install an alcohol-fueled engine to drive a screw compressor, recover waste heat and use it to drive an absorption chiller. The absorption chiller would provide 40 degrees F chilled water for the first stage of hydrocooler cooling. Final cooling would be provided by the existing system with 33 degrees F water. This scheme would reduce electricity energy use and demand charges by an estimated $25,480 annually. However, there the cost of the alcohol must also be considered. The estimated installed cost of the engine, heat recovery equipment, absorption chiller, and additional cooling tower capacity is $131,000. The cost savings do not justify retrofitting at current energy costs. However, this scheme should be considered when adding refrigeration capacity for the new hydrocooler.

Absorption-Assisted Refrigeration. Install an alcohol-fueled engine to drive a screw compressor and recover waste heat to drive an absorption chiller as above. However, use the absorption chiller to provide condenser water for the ammonia refrigeration machine. Condenser water temperatures could be lowered from about 85 to 60 degrees F, which would increase the COP of the ammonia machine dramatically. The estimated energy cost savings is $31,110. The cost to retrofit is estimated at $410,000. This is not an economically attractive ECM at current electric rates.

Add Insulation to Bin Coolers and Cold Storage Rooms. Adding 2 inches of urethane boardstock insulation to walls and ceiling would result in an energy cost savings of about $1,350 annually. However, the cost to add insulation, cover with 3/4-inch plywood, and finish with epoxy paint would cost about $123,000. This retrofit will probably never be cost-effective. However, when new cold storage facilities are added, use of more insulation should be investigated.

CHAPTER 3

BIOMASS PROFILE

Agricultural residue as a fuel represents a substantial energy potential. This chapter identifies the types, quantities, location, and availability of residues in the study area. Cull fruit is discussed separately because of its potential for alcohol production. All other agricultural wastes are considered as potential fuel sources for power production.

AGRICULTURAL RESIDUES

Agricultural wastes are divided into four categories: field crop residue, vegetable crop residue, orchard prunings, and animal manure. Field crop residue is considered to be all vegetative material, from the ground up, left behind the harvester. In general, it is characterized by a low moisture content (10 to 20 percent). For example, wheat straw, barley straw, and corn stover fall into this category. Vegetable crop residue is all vegetative material left after harvest, excluding any remaining crop material. It typically has a high moisture content (80 to 95 percent). Lettuce, tomato, potato, and melon remains are in this category. Orchard prunings are available from tree fruit and nut orchards and from grape vineyards. They typically have a moisture content of about 30 percent. Animal manure is produced at feedlots, dairies, and poultry operations as a point-source residue. Manure has a high moisture content, typically 80 percent or higher.

The study area is approximately all the land within a 50-mile radius of Sanger. For estimating purposes, all of Fresno, Kings, Madera, and Tulare Counties have been included. Data on crop production is available every year on a county-by-county basis. Each county's 1980 Agricultural Crop and Livestock Report was used to determine the various types and quantities of agricultural products in the study area. Once the quantity of a product is determined, a residue factor is applied and the amount of agricultural residue is estimated. The estimated quantity of each type of agricultural residue is presented in Tables 3-1 through 3-4.

Several points must be kept in mind when using these tables. First, these figures are estimates of average residue production. Actual residue production varies from location-to-location and from season-to-season just as crop production varies. Second, these

Table 3-1 1980 Field Crop Residue Production

Crop	Crop production, thousand tons				Residue factor[a]	Moisture, percent[b]	Residue production, 1,000 dry tons
	Fresno	Kings	Madera	Tulare			
Barley	223.0	145.9	19.5	107	2.5	10	1,114.7
Beans, dry	7.8	-	3.2	10.4	1.05	20	18.0
Corn	20.7	34.4	27.8	53.1	1.10	20	116.2
Cotton	424.0[c]	286.0	56.5	176.7	1.5[d]	20	1,131.8
Rice	30.9	9.7	-	12.4	1.43	20	60.6
Safflower	19.3	31.1	-	-	0.83	10	37.6
Sorghum	7.2	11.9	4.7	39.9	1.57	20	80.0
Sugar beets	633.0	29.4	151.0	233.0	.52	80	108.8
Wheat	238.0	111	137.0	197.0	1.25	10	768.4
Total							3,436.1

[a] Tons per ton of production.

[b] Estimated moisture content at time of collection.

[c] Thousands of acres.

[d] 1.5 tons per acre.

Table 3-2 1980 Vegetable Crop Residue Production

Crop	Production, 1,000 tons				Residue factor[a]	Moisture, percent	Residue production, 1,000 dry tons
	Fresno	Kings	Madera	Tulare			
Beans, snap	1.98	-	-	-	1.05	80[d]	0.42
Cucumbers	-	-	-	532[b]	1.7[c]	-	0.90
Galric	24.2	-	-	-	0.30	89[d]	0.80
Lettuce	139.3	50.7	-	-	0.96	94	10.9
Melons	230.5	15.9	-	-	0.65	85	24.0
Onions, dry	119.6	7.8	-	-	0.30	89	4.2
Peppers	-	-	-	720[b]	1.2[c,d]	-	0.9
Squash	482[b]	-	-	-	1.2[c]	-	0.6
Sweet potatoes	6.0	-	-	-	0.55	81	0.6
Tomatoes	1,095	26.2	32.0	50.3	1.0	80	240
Total							282.7

[a] Tons of residue/ton of crop.

[b] Acres.

[c] Tons per acre, dry weight.

[d] Estimate based on similar vegetables.

Table 3-3 1980 Fruit and Nut Crop Residue Production

Crop	Harvested acres, acres				Residue factor, tons/acre	Moisture content, percent	Residue production, 1,000 dry tons
	Fresno	Kings	Madera	Tulare			
Almonds	23,992	4,847	19,960	8,504	1	30	40.1
Apples	-	-	47	123	1	30	0.1
Apricots	236	91	54	164	1	30	0.4
Avacados	324	-	-	1,421	1	30	1.2
Boysenberries	275	-	-	-	1	30	0.2
Citrus	20,864	-	3,362	81,000	1	30	73.7
Figs	6,980	-	2,822	-	1	30	6.9
Grapes	187,854	3,411	56,817	32,190	1	30	196.1
Nectarines	9,836	463	278	5,985	1	30	11.6
Olives	1,578	1,162	1,826	13,259	1	30	12.5
Peaches	10,191	1,996	1,379	4,336	1	30	12.5
Pears	142	-	-	215	1	30	0.2
Pecans	203	-	-	-	1	30	0.1
Persimmons	49	-	-	286	1	30	0.2
Pistachio nuts	271	2,792	8,339	883	1	30	8.6
Plums	12,252	1,116	633	11,213	1	30	17.6
Pomegranates	965	-	-	1,519	1	30	1.7
Prunes	418	-	-	4,071	1	30	3.1
Strawberries	105	-	-	-	1	30	0.1
Walnuts	3,551	4,485	1,196	24,314	1	30	23.5
Miscellaneous	185	306	-	394	1	30	0.6
Total							411.2

[a] Prunning only, does not represent culls.

Table 3-4 1980 Manure Production

Source	Number of head				Residue factor	Moisture, percent	Residue production, 1,000 dry tons
	Fresno	Kings	Madera	Tulare			
Beef	413,200	65,200	29,900	157,600	1.0[a]	30	466.1
Dairy	68,300	65,600	16,500	-[b]	2.25[c]	80	67.8
Hogs and pigs	15,300	1,200	1,400	74,000	0.18[d]	-	16.5
Poultry	68,888,000	2,222,000	4,870,000	4,370,900	2.4[e]	25	144.6
Total							695

[a] One ton per animal per year as received.

[b] Included in beef.

[c] 2.25 tons of manure per cow, includes wash water from barns.

[d] lb/animal/day, dry weight.

[e] Tons of manure per 1,000 hens.

figures will, of course, change from year-to-year as cropping patterns change. For some crops, such as fruit and nut orchards or grape vineyards, such changes usually occur slowly. For field and vegetable crops, such changes can occur rapidly. Third, these figures include all residue from the ground up. Pickup of all the residue may not be feasible.

Once the type and quantity of agricultural residue is determined, location is the next concern. For example, how much of a certain crop is grown within a 15-mile radius of Sanger. This information is not readily available from local agricultural officials because it is often considered confidential and detailed distribution of crops in the study area is beyond the scope of this work. However, general trends in cropping patterns are helpful. Estimates of general cropping patterns in each county were established by conversations with county agricultural officials. Figure 3-1 presents this information.

Simple inspection of the residue quantities presented in Tables 3-1 through 3-4 and cropping patterns shown on Figure 3-1 indicate that there are sufficient amounts of biomass to supply a large-scale power plant. However, other factors besides quantity affect the selection of agricultural residues as a biomass fuel. These are discussed in the following section.

Feasibility as Biomass Fuel

Many factors can influence the selection of an agricultural residue as a biomass fuel, but certainly one of the most important is cost. Previous studies have made two important findings. First, collection costs typically dwarf transportation costs. Transporting point-source residues additional distances is more feasible than collecting more proximal field residues. Second, vegetable crop residues are generally not feasible as biomass fuels. High moisture content lessens the unit energy content and increases the collection and transportation costs. With this in mind, vegetable crop residue will not be considered further. The following discussion will focus on those field-crop and point-source residues which can be cost-effective fuels.

The following is a list of the different residues which are suitable biomass fuels, based on delivery cost:

1. Pomace
2. Fruit pits
3. Steer manure
4. Cotton gin trash
5. Orchard prunings
6. Grape prunings
7. Wheat straw

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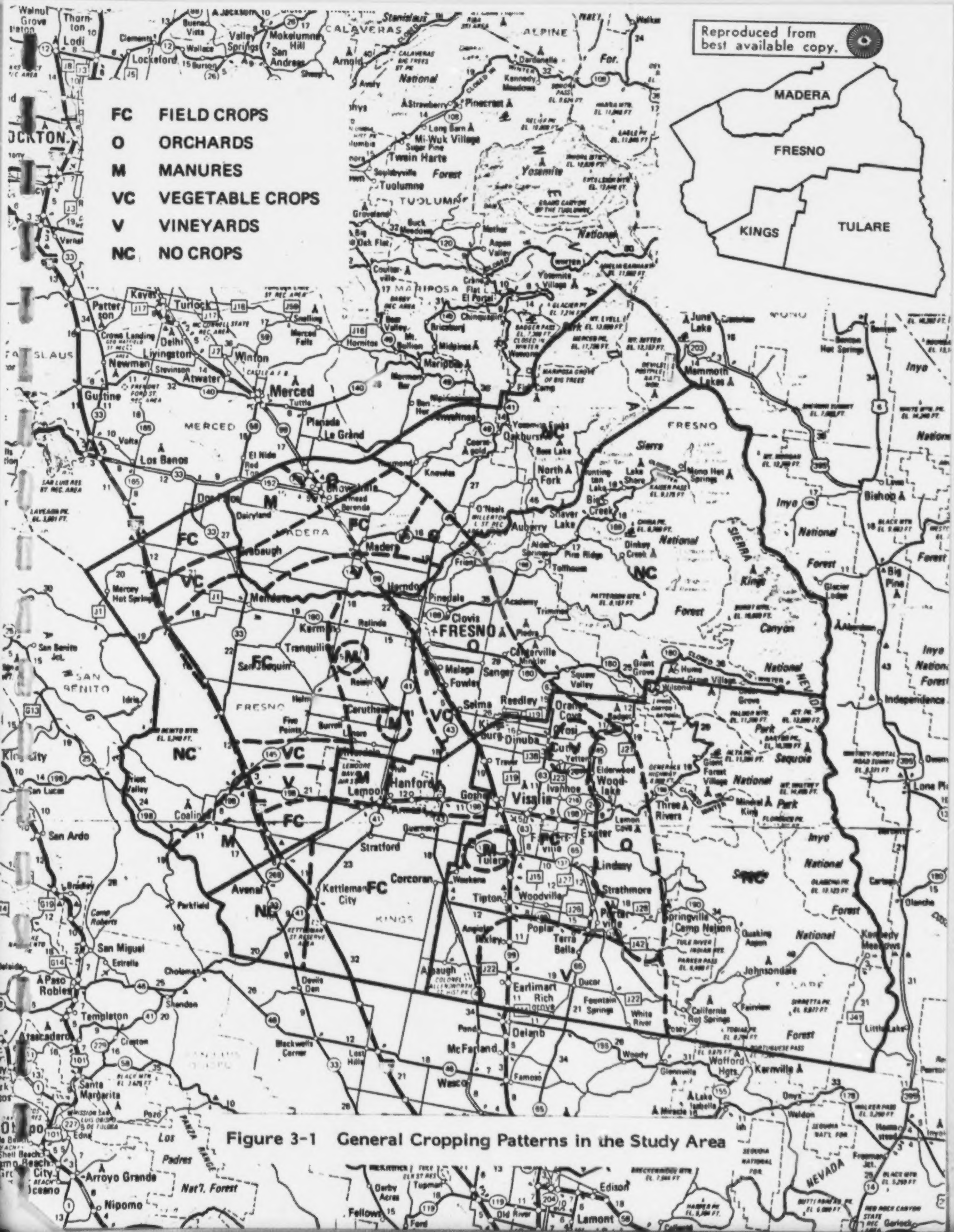

FC FIELD CROPS
O ORCHARDS
M MANURES
VC VEGETABLE CROPS
V VINEYARDS
NC NO CROPS
MADERA
FRESNO
KINGS
TULARE
Merced
Madera
FRESNO
Hanford
Visalia
Tulare
Porterville
Coalinga
Corcoran
Kettleman City
Lemoore
Delano
MERCED
MADERA
FRESNO
KINGS
FC
O
M
VC
V
NC

Figure 3-1 General Cropping Patterns in the Study Area

8. Cotton stalks
9. Barley straw
10. Field corn stover

The clearest way of understanding delivery costs is by expressing the cost in terms of dollars per million British thermal units (Btus). This value includes the influence of energy content, moisture content, collection cost, and transportation costs. Because the delivery cost depends on transportation distance, three distances have been choosen for comparison. They are 15, 30, and 50 miles. Fifty miles from Sanger is essentially the study area limit. The unit delivery costs are summarized in Table 3-5. Table 3-6 presents similar information, but on a dollar-per-ton basis.

The differences in costs between residues in both Tables 3-5 and 3-6 is due primarily to differences in collection cost. Gathering field residues, transporting them to a central on-farm location, and packaging them for haul, is considered collection. Field crop residue and grape prunings incur higher delivered costs due to expensive field collection operations. However, large quantities and possible air pollution emission offsets, due to a reduction in open field burning, are advantages of these residues. Process residues, such as cotton trash, fruit pits, pomace, and manure are by-products of industrial crop processing. These residues are available at a point source and therefore, have the lowest unit costs.

Moisture content is also an important factor in the unit cost differences. Energy content of agricultural and livestock residues does not vary widely on a dry-pound basis. Table 3-7 lists the energy content of each residue. The values range from a low of 7,300 Btus per dry pound to a high of 8,500 Btus per dry pound. However, moisture content must be considered to accurately describe the energy content of a residue. For example, a residue with 80 percent moisture, and an energy content of 8,000 Btus per dry pound (such as dairy manure) is collected, transported, and received as a material with an energy content of only 1,600 Btus per pound on an as-received basis. The low (on an as-received basis) energy content significantly reduces the value of the residue as a biomass fuel. A large amount of moisture must be collected, handled, and transported. The costs associated with this can be prohibitive.

Another important consideration is the seasonal availability of many supplies. Generally, harvest begins in mid-June and lasts until mid-November. Tree crops are pruned during winter. Table 3-7 indicates the times when certain residues become available. Because of weather conditions, crops that are harvested late in the fall may not have residue available for pickup until spring. Continuous operation of a biomass-fueled energy production plant depends on a steady supply of residues. Since most crop

Table 3-5 Unit Delivery Costs

Residue	Dollars per million Btu		
	15-mile radius	30-mile radius	50-mile radius
Cotton trash	0.37	0.42	0.48
Pomace[a]	1.30	1.42	1.60
Fruit pits	0.28	0.31	0.36
Cotton	1.50	1.52	1.62
Field corn	1.49	1.57	1.68
Barley	1.46	1.54	1.64
Wheat	1.40	1.46	1.56
Grape prunings	1.39	1.44	1.51
Orchard prunings	0.96	1.01	1.09
Beef manure	-	1.00	1.11
Dairy manure	-	2.06	2.38

[a] Cost of pomace may be slightly lower since a significant quantity is generated at the Gibson Winery.

Table 3-6 Costs of Delivery to the United Packings Sanger Plant

Residue	Dollars per ton[a]		
	15-mile radius	30-mile radius	50-mile radius
Cotton trash	4.95	5.50	6.44
Pomace[b]	6.50	7.10	8.00
Fruit pits	4.95	5.50	6.45
Cotton	16.25	16.60	17.55
Field corn	18.70	19.70	21.10
Barley	20.10	21.10	22.50
Wheat	20.10	21.10	22.50
Grape prunings	17.30	17.90	18.75
Orchard prunings	11.10	18.30	12.60
Beef manure	-	11.25	12.30
Dairy manure	-	6.60	7.70

[a] Values shown in mid-1981 dollars.

[b] Cost of Gibson's pomace could be much lower since minimal transportation costs are incurred.

Table 3-7 Residue Characteristics

Residue	Energy content, Btu per dry pound	Seasonal availability
Cotton trash	7,300	Mid-September to mid-January
Pomace	8,000	Mid-August to mid October
Peach pits	8,500	Mid-July to mid-September
Cotton	6,800	Fall and winter
Field corn	7,850	Late summer and fall
Barley	7,600	Spring and summer
Wheat	8,000	Spring and summer
Grape prunings	8,300	Winter
Orchard prunings	8,300	Winter
Beef manure	8,000	Year-around
Dairy manure	8,000	Year-around

Table 3-8 Cull Fruit Production at Sanger

Month	Culls as a percentage of incoming fruit		
	Peaches	Plums	Nectarines
May	31	16	48
June	36	39	31
July	33	36	34
August	29	58	39
September	28	42	41
October	60	-	-
Average	36.2	38.2	32.2

residues only become available in certain seasons, large storage capacity is required at the plant to ensure a continuous supply during those times when little residue is available. Increased storage requirements will increase a project's capital cost. Another problem is the danger of spontaneous combustion in the storage bins. These drawbacks can be minimized by two approaches. One approach is to select a combination of residues as the biomass fuel. The contributing residues become available during different seasons of the year, thus reducing seasonal shortages of biomass. The combination alternative depends significantly on the size and type of process used for energy production. A second, less complicated approach, would be to use a residue that is constantly available throughout the year. Only manure has this characteristic among the wastes studied.

Residue value is also influenced by the availability of markets, the composition, and disposal requirements. Because of increased environmental awareness, many farmers, processers, and cattlemen appear to consider residues more as by-products than wastes. Returning residues to the land for regeneration of the soil is partially replacing simple disposal and open field burning. The value of residues as cattle feed is becoming more apparent as well. In the contracting procedure for the residues, sellers will become aware that their residues are in demand and could be an asset rather than a liability. Because of the increased interest in the residues, farmers may raise the price they charge. This may reduce the economic attractiveness of this source as shown in prior cost feasibility analyses. In view of this, contracting must be carefully handled so that residue procurement costs do not escalate unreasonably.

CULL FRUIT

The major fruit culls available at United Packing's Sanger plant are peaches, plums, and nectarines. Minor quantities of other fruit such as kiwi, pomegranates, and persimmons, for example, are also available; however, they are not considered in this report. The quantity of cull fruit at the Sanger plant as a percentage of the incoming fruit is presented in Table 3-8. These data are based on the 1980 packing season and are for peaches, plums, and nectarines only. The total quantity of culls is 7,610 tons per year. This includes about 3,767 tons per year of plums, 2,102 tons per year of peaches, and 1,740 tons per year of nectarines. Not mentioned in Table 3-8 are melons. Though not available at the Sanger plants, 1,200 tons of melon culls are disposed of annually from other United Packing sheds. These melon culls can also serve as a feedstock for alcohol production.

As directed by United Packing, neighboring packing sheds were not surveyed to determine how much cull fruit is available in the area. Therefore, for the purpose of this study, an estimate of eight times the available culls at the Sanger plant (60,888 tons per year) is used. This is based on guidance provided by United Packing personnel. Other packing sheds in Sanger include the firms of Barr Packing and Ballantine Packing. Fresno-based firms include Bonner Packing, ATHWAL BROS., and Central Valley Packing.

Data on the 1980 fresh fruit production in the study area are summarized in Table 3-9. The total annual production (tons) of fresh peaches, plums, and nectarines is 131,881, 181,775, and 188,207, respectively. If the percent culls shown in Table 3-8 are applied to these production figures, an estimated 47,741 tons of peach culls, 69,438 tons of plum culls, and 60,603 tons of nectarine culls are produced annually. The total cull production is 177,782 tons. The estimated quantity of 60,880 tons calculated by United Packing compares favorably (34 percent) with this value. In addition, data indicate that about 8,970 tons of freestone peaches and 78,440 tons of cling peaches are processed annually. This suggests that approximately 5,100 tons of peach pits could be available as a fuel source.

Table 3-10 presents the data on some key parameters of the cull fruit. The data are from the literature, with the exception of sugar content which was confirmed with laboratory tests on a sample of fruit obtained in September 1981. The data in Table 3-10 will vary with variety, maturity, and time of picking.

Table 3-9 1980 Fresh Fruit Production in the Study Area

County	Production, 1,000 tons		
	Peaches[a]	Plums	Nectarines
Fresno	82,100	90,800	117,000
Kings	7,481	5,591	4,727
Madera	6,600	4,684	2,780
Tulare	35,700	80,700	63,700
Total	131,881	181,775	188,207

[a] Freestone only.

Table 3-10 Key Parameters on Fruit at Sanger

Fruit type	Percent fermentable (sugar content)	Potential ethanol yield per ton,[a] gallons
Peaches	9	10
Nectarines	9	10
Plums	11	11

[a] Data obtained from California Department of Food and Agriculture and is known to vary by fruit variety, etc.

CHAPTER 4

ALCOHOL PRODUCTION ALTERNATIVES

This chapter examines various alcohol production scenarios and end uses for the alcohol. Two alcohol production cases are considered: (1) process only the cull available at United Packing's Sanger plant, or (2) process fruit culls from the Sanger plant plus the culls from seven additional packing sheds. Alcohol production deals not only with fermentation and distillation, but also with feedstock preparation and disposal of distillation byproducts (stillage). End use of the alcohol is discussed at the end of the chapter.

ALCOHOL PRODUCTION

In this section, we discuss the feedstock preparation process, the fermentation and distillation scenarios, and the stillage disposal alternatives. However, before a detailed discussion of alcohol production alternatives is presented, it is appropriate to briefly describe the alcohol production process.

Ethanol Production

Ethanol (ethyl alcohol) is produced from the anaerobic fermentation of simple sugars. The simple biological conversion of sugar into ethanol and carbon dioxide by yeast is represented by the chemical equation:

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2 + \text{Heat}$$

$$\text{1 Glucose} \longrightarrow \text{2 Ethanol + 2 Carbon Dioxide + Heat}$$

Every molecule of glucose yields two molecules of ethanol. This is a theoretical yield of 51 pounds ethanol for every 100 pounds glucose. In actual practice, the yield will be somewhat less, or around 47 to 49 pounds of ethanol per 100 pounds sugar. This means that it takes about 13.5 to 14 pounds of sugar to produce 1 gallon of alcohol.

Ethanol can usually be fermented easily and with a minimum of difficulties. Yeasts used in ethanol production are members of the genus Saccharomyces. These yeasts are sensitive to a wide variety of variables that can potentially affect ethanol production. However, pH and temperature are the most influential of these variables and these can usually be easily controlled.

Saccharomyces are most effective in pH ranges between 3.0 and 5.0 and temperatures between 80 degrees Fahrenheit (F) (20 degrees centigrade (C)) and 90 degrees F (35 degrees C). The length of time required to convert a mash to ethanol depends on the number of yeast cells per quantity of sugar. A greater number of yeasts will convert the glucose to ethanol more quickly, up to a point of diminishing returns.

Some heat is generated during the fermentation process. The absolute maximum is around 10 to 15 British thermal units (Btus) per gallon-hour, but most of the time it is much less than this. This corresponds to a temperature rise of 1 to 2 degrees F per hour if no heat is removed. Large fermentors require some form of cooling, but small fermentors with sufficient surface area per unit volume may lose enough heat naturally.

Once all the sugars are converted to ethanol, fermentation is complete. This ethanol-water mixture is referred to as distillers material (DM). Now the ethanol must be separated from the DM by distillation. Distillation is a separation process which depends on the fact that some components are more volatile than others. Thus, in a boiling liquid mixture the vapors coming off will have a higher concentration of the more volatile component than the original solution. There are three main types of distillation systems: batch (pot) distillation, batch (pot) rectification, and continuous distillation.

The most efficient type of distillation operation is the continuous (stripper-rectifier) method. Here a column containing many (usually 40 or more) plates (trays) is used. The DM is fed continuously into the column near the center. As the liquid flows down over the trays, it is stripped of alcohol by upcoming vapors. By the time it reaches the bottom, it should have no alcohol left. Above the feed point, the vapors continue to become enriched in alcohol at each tray, as they are contacted with alcohol-rich liquid being refluxed. The vapors exiting the top should be at maximum strength, around 95 percent alcohol by volume (the maximum attainable for an ethanol-water mixture). A portion of the stream condensed at the top must be refluxed back into the column and the rest is the product stream. The percent alcohol in the product can be controlled by amount of reflux.

The removal of the last 5 percent of water from the 190-proof alcohol requires special distillation techniques known as azetropic distillation. This entails the addition of a third organic component (such as benzene, cyclohexane, pentane, etc.). A pure alcohol stream then exits the bottom of the azetrope column, while a three-component mixture exits the top, requiring further separation and solvent recovery. This report does not consider anhydrous alcohol.

Feedstock Preparation

The cull fruit must be pitted, pulped, pasteurized, and cooled prior to fermentation. To accomplish this, a screw cooker, pulper, and cooler are needed. Cull fruit is conveyed from the packing lines to a surge bin. Fruit is fed from the bin to the screw cooker at a constant rate, by means of a screw conveyor. The softened fruit goes to the pulper where the pits are removed and the fruit is mashed. Hot mash is pumped to the cooler where the temperature is lowered before fermentation. Cull fruit is only processed in at the rate at which it can be fermented and no storage of pulp is required. Figure 4-1 is a flowsheet of the feedstock preparation process which is recommended for use with all of the alcohol production alternatives.

The function of the screw cooker is to soften and pasturize the fruit. Because many of the culls are green, the pulper alone would be insufficient to remove the pits. The screw cooker, sized for 12 tons per hour maximum capacity, is 16 inches in diameter by 15 feet long. Detention time in the cooker is 20 to 30 minutes. Approximately 3,000 pounds per hour of low pressure (10 pounds per square inch (psi)) steam is needed at maximum capacity, while the steam needed for average conditions is 1,250 pounds per hour. Steam can be supplied from the same boiler which supplies the still. The steam added to the cooker maintains the temperature at 180 degrees F. This temperature is sufficient to kill micro-organisms which die in the range of 150 to 170 degrees F. The units are all stainless steel construction and cost approximately $25,000 new. However, used units are often readily available. Typical suppliers are Atlas Pacific, Emeryville; Fran Rico Corporation, Stockton; Process Engineers, Hayward; South Valley Manufacturing, Gilroy.

The function of the pulper is to separate pits from the softened fruit and mash the pulp. The pulper is sized for 14 tons per hour, 12 tons of fruit and 2 tons of condensate. This would require an FMC model 100 or its equal. Cost for a unit is approximately $20,000 new and $6,000 for a used pulper. Typical suppliers are FMC, San Jose; Brown International Corporation, Covina; and Langsingcamp, Virginia, Indiana.

The cooler lowers the temperature of the mash for fermentation. If the mash was sent directly to the fermentor, yeast would die because of the high temperature. The cooler is sized to remove 2,500,000 Btus per hour and requires a maximum 100 gallons per minute (gpm) of water. A typical cooler is manufactured by South Valley Manufacturing Company, Gilroy. A new cooler, complete with controls, costs $20,000. Used coolers are not usually available.

A cooling tower is needed to cool the 100 to 150 gpm of recirculation water. The water enters the cooling tower at approximately 128 degrees F and is cooled to 78 degrees F before

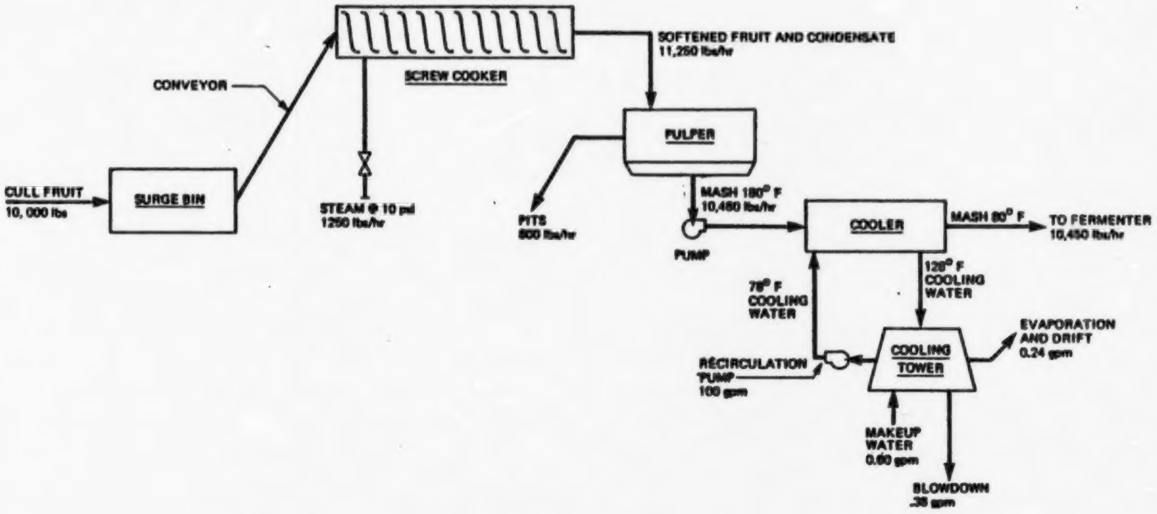

CULL FRUIT
10, 000 lbs
SURGE BIN
CONVEYOR
SCREW COOKER
STEAM @ 10 psi
1250 lbs/hr
SOFTENED FRUIT AND CONDENSATE
11,250 lbs/hr
PULPER
PITS
800 lbs/hr
MASH 180° F
10,450 lbs/hr
PUMP
COOLER
MASH 80° F
TO FERMENTER
10,450 lbs/hr
75° F
COOLING
WATER
120° F
COOLING
WATER
RECIRCULATION
PUMP
100 gpm
COOLING
TOWER
EVAPORATION
AND DRIFT
0.24 gpm
MAKEUP
WATER
0.60 gpm
BLOWDOWN
.36 gpm

Figure 4-1 Feedstock Preparation Schematic

exiting. One available unit is the Marley model NC cooling tower. The tower costs about $8,200. Foundation costs of $3,000 increase the total cost to $11,200 for the tower. However, it may be possible to eliminate the cooling tower if other sources of cool water are available (i.e., DM or boiler water). The heat transferred from the mash can be used to preheat the DM prior to distillation. A water treatment system is not needed for the cooler or cooling tower. Typically, in the food processing industry, a weekly dosing with bleach is all that is done to control algae growth in the system.

A summary of the capital and operation and maintenance (O&M) costs for the feedstock preparation system is presented in Table 4-1. Prices for both new and used equipment are provided.

Alcohol Production Scenarios

All the alcohol production scenarios described below produce 190-proof ethanol. This is not to say that production of other proofs in the range of 160 to 190 is not feasible. All the alcohol production scenarios described are capable of producing any proof ethanol in the range of 160 to 190 without any change in the capital costs and with a small savings in O&M costs. The primary O&M reduction will be in fuel savings to produce steam for distillation. However, it has not been possible to quantify this savings within the accuracy of the cost figures presented. Production of 160-proof instead of 190-proof ethanol will yield more gallons of ethanol (80,000 gallons of 160-proof, compared to 60,900 gallons of 190-proof). However, the heating value per gallon will be proportionally lower and it will take more gallons of 160-proof than 190-proof to produce the same amount of energy. For these reasons, the report has been limited to a discussion of 190-proof ethanol.

The alcohol production alternatives include the following:

Alternative	Description
A	Process only culls available at Sanger facility and:
A-1	Purchase equipment; fuel with natural gas.
A-2	Purchase equipment; fuel with biomass.
A-3	Lease equipment; fuel with natural gas.
B	Process culls from Sanger facility and seven additional packing sheds using Gibson Winery.

For the following discussion, it is assumed that 190-proof ethanol is the product, although it is possible to operate engines

Table 4-1 Capital and Operation and Maintenance Costs for the Feedstock Preparation System

Component	Cost, dollars	
	New	Used
Capital		
Screw cooker	25,000	10,000
Pulper	20,000	6,000
Cooler	20,000	20,000
Pumps	4,000	4,000
Cooling tower	11,200	11,200
Miscellaneous piping and electrical at 15 percent of new cost	12,000	12,000
Subtotal equipment	92,200	63,200
Sales tax	5,500	3,800
Shipping	4,000	4,000
Installations	46,100	31,600
Engineering and contingencies at 25 percent	37,000	37,000
Total capital cost	184,800	139,600
Annualized capital cost at 20 percent, 10 years	44,100	33,300
Operation and maintenance		
Power at $0.06 per kwhr	2,400	2,400
Labor at $8 per hour	0[a]	0[a]
Water	100	100
Steam (natural gas) at 1,460 pounds per hour	14,500	14,500
Maintenance	1,000	1,000
Insurance at 1 percent of capital	900	600
Total operation and maintenance (for feedstock preparation)	18,900	18,600
Total annual cost	63,000	51,900
Cost per gallon (60,888 gallons) for feedstock preparation	1.03	0.85

[a] Included in alcohol production costs.

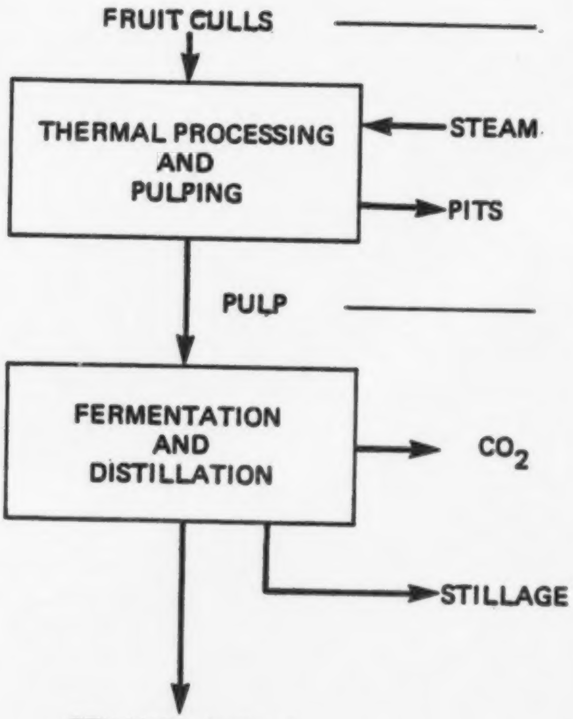
on 160- to 190-proof. A discussion of the various pros and cons of operating engines on different proof alcohol fuels is included in the next section on end use of the alcohol.

Alternative A-1. In this alternative, United Packing would purchase all the necessary fermentation, distillation, and steam boiler equipment to produce 60,900 gallons per year. Because of fluctuations in cull availability, the alcohol production capability of the unit should vary from 135 gallons per day (gpd) to 780 gpd. A mobile alcohol refinery unit capable of producing 40 gallons per hour (gph) is commercially available from Parallel Products (see Appendix A). The estimated cost for the unit is $245,000, which includes fermentor, distillation columns, and a natural gas-fired boiler. An additional $20,000 has been included for a boiler with capacity to supply both the screw cooker and distillation equipment. The mass and energy balances are shown in Figure 4-2 and 4-3, respectively.

Distillation using the Parallel Products system requires 30,000 Btus per gallon of alcohol. This percentage is due to the addition of water (steam) in the feedstock preparation phase. The waste pulp, skins, and pits amount to 101 percent of the initial cull input. In other words, each ton of cull fruit processed for ethanol generates 2,027 pounds of byproducts (stillage and pits). Capital and operation and maintenance costs for Alternative A-1 are presented in Table 4-2. No salvage value has been assumed for the mobile refinery. All costs are based on June 1981 dollars and do not consider inflation.

Alternative A-2. This alternative is identical to Alternative A-1 except that biomass (e.g., peach pits) is used to fire the boiler. Assuming that 30,000 Btus per gallon of alcohol is required to operate the fermentation and distillation equipment and a biomass boiler efficiency of 70 percent, yields an energy input requirement of 42,860 Btus per gallon. Pits are approximately 8 percent by weight of the cull fruit; this equals 160 pounds per ton. At a 15 percent moisture content, the dry weight of the pits is 136 pounds per ton. Assuming a heating value of 8,500 Btus per dry pound for fruit pits, the total energy available from the pits is 1,156,000 Btus per ton of culls or 5.78×10^6 Btu per hour. This is equal to 144,500 Btus available per gallon of ethanol, well in excess of the 42,860 Btus per gallon energy input requirement. The excess energy can be used in the screw cooker for feedstock preparation. The energy balance is presented on Figure 4-4 and the mass balance is identified on Figure 4-2.

Figure 4-4 is identical to 4-3, except that the pits are used for fuel. This reduces the waste products to approximately 99 percent of the initial cull input. On the average, only 4.13×10^6 Btu per hour are needed to fire the boiler, with


THERMAL PROCESSING AND PULPING
FERMENTATION AND DISTILLATION

	QUANTITY, tons	
	YEARLY	HOURLY
FRUIT CULLS	7611	5.0
STEAM	1111	0.73
PITS	609	0.40
PULP	8113	5.33
CO_2	200	0.13
STILLAGE	7712	5.07
ETHANOL, (gallons)	201 (60,888)	0.13 (40)

Figure 4-2 Mass Balance for Alcohol Production Alternative A-1

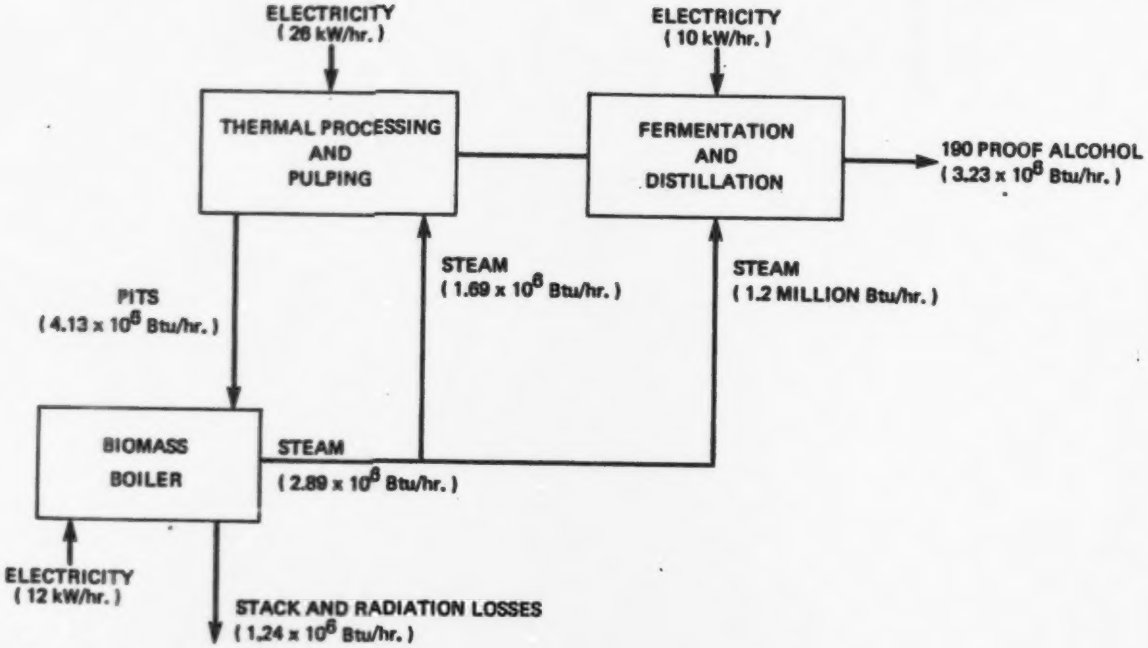

ELECTRICITY
(26 kW/hr.)
THERMAL PROCESSING AND PULPING
ELECTRICITY
(10 kW/hr.)
FERMENTATION AND DISTILLATION
190 PROOF ALCOHOL
(3.23×10^6 Btu/hr.)
PITS
(4.13×10^6 Btu/hr.)
STEAM
(1.69×10^6 Btu/hr.)
STEAM
(1.2 MILLION Btu/hr.)
BIOMASS BOILER
STEAM
(2.89×10^6 Btu/hr.)
ELECTRICITY
(12 kW/hr.)
STACK AND RADIATION LOSSES
(1.24×10^6 Btu/hr.)

Figure 4-3 Energy Balance for Alcohol Production Alternative A-1

Table 4-2 Capital and Operation and Maintenance Cost for Alternative A-1

Cost component	Dollars
Capital	
Mobile refinery	245,000
Sales tax at 6 percent	14,700
Subtotal equipment cost	259,700
Contingencies at 10 percent	26,000
Total capital cost	285,700
Annualized capital cost at 10 years, 20 percent	68,100
Annual operation and maintenance	
Yeast and chemicals at $0.018 per gallon	1,100
Electricity at $0.06 kwhr	900
Labor at $8 per hour	12,200
Maintenance at 6 percent of capital	13,500
Insurance at 1 percent of capital	2,300
Natural gas at $0.45 per therm	10,300
Total annual operation and maintenance (ferment and distill)	40,300
Total annual cost	108,400
Cost per gallon (60,888 gallons) not including feedstock preparation	1.78

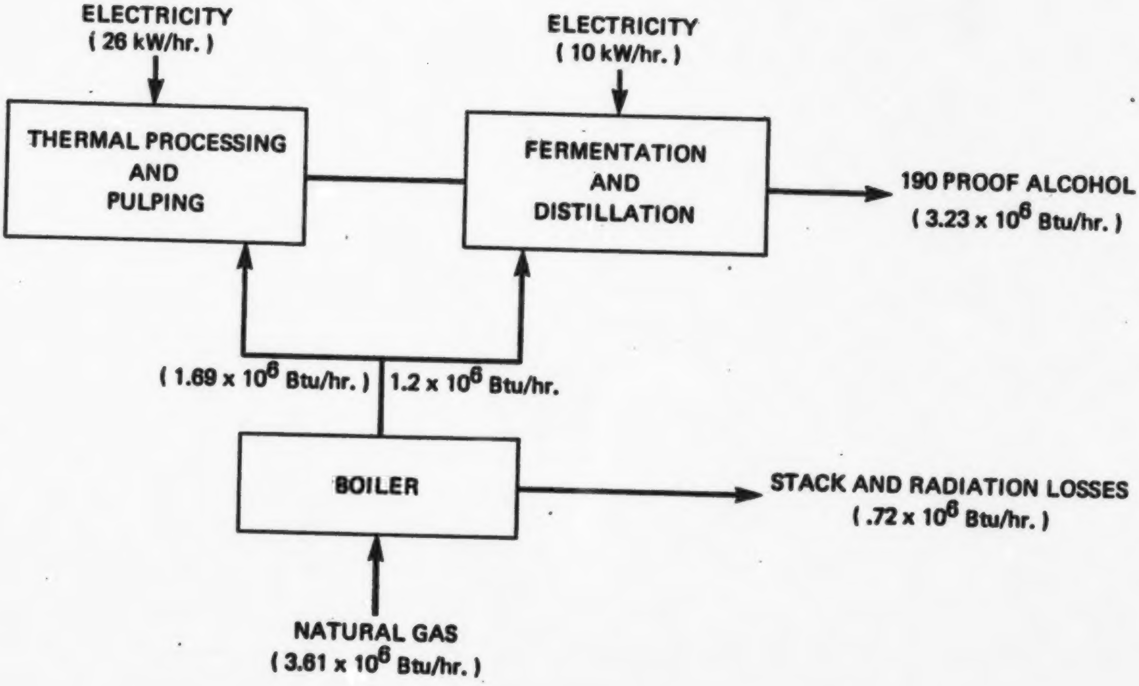

ELECTRICITY
(26 kW/hr.)
THERMAL PROCESSING AND PULPING
ELECTRICITY
(10 kW/hr.)
FERMENTATION AND DISTILLATION
190 PROOF ALCOHOL
(3.23 x 10^6 Btu/hr.)
(1.69 x 10^6 Btu/hr.)
1.2 x 10^6 Btu/hr.
BOILER
STACK AND RADIATION LOSSES
(.72 x 10^6 Btu/hr.)
NATURAL GAS
(3.61 x 10^6 Btu/hr.)

Figure 4-4 Energy Balance for Alcohol Production Alternative A-2

5.78×10^6 Btu per hour available from the pits. Therefore, 228 pounds per hour or 174 tons annually would not be utilized. At peak throughput 4.06×10^6 Btus per hour are required for the screw cooker. This peak , plus the distillation requirements can be met with the available pits. Capital and O&M costs are presented in Table 4-3.

Alternative A-3. With this option, United Packing would contract with Parallel Products to furnish all the equipment including the feedstock preparation equipment at an estimated cost of $0.60 per gallon of ethanol produced (as of July 1981). All electricity, natural gas, and labor would be supplied by and paid for by United Packing. In addition, approximately $20,000 would be charged for the extra boiler capacity to meet both the feedstock preparation and distillation steam needs. The mass and energy balances are identical to Figure 4-2 and 4-3, respectively. The capital and operational costs are presented in Table 4-4.

The operational costs are only for fermentation and distillation. It is assumed that the feedstock preparation equipment described earlier would be used, and that operational costs, excluding maintenance, are identical, at a cost of $0.31 per gallon. Therefore, the cost to produce 60,088 gallons of ethanol is $79,900 in the first year, plus $18,900 for feedstock preparation capital and operation.

Alternative B. In this alternative, the facilities at Gibson Winery would be used to ferment and distill. It is assumed that United Packing would have to provide the feedstock processing. At this time, a firm price to process the DM has not been received from Gibson. However, in the wine industry, the cost to ferment and distill DM is near $0.45 per proof gallon (e.g., a proof gallon has an alcohol content of 50 percent). This equals $0.86 per gallon of 190-proof alcohol. Assuming a 40 percent profit and contingency for Gibson raises the cost to $1.20 per gallon. The additional cost of feedstock preparation at $1.03 per gallon brings the total cost to United Packing to $2.23 per gallon of alcohol (not including sewer charges), if only culls available at Sanger are processed.

This estimate appears to be reasonable. In conversations with Mike Nurey at Vie Del Winery, an estimate of $20 per ton was given to process cull fruit to alcohol. However, this is not a firm price. It does not include transportation to the site, and assumes that 8 gallons of alcohol are produced per ton, yielding $2.50 per gallon.

The Gibson facilities could also be used for culls from seven additional packing sheds. An estimate of total cull availability from all eight facilities is 60,800 tons per year, varying from 4,050 tons in May to 23,400 tons in July. Thus, at the peak of

Table 4-3 Capital and Operation and Maintenance Cost for Alternative A-2

Cost component	Dollars
Capital	
Mobile refinery with biomass boiler	327,000
Sales tax	19,600
Total equipment cost	346,600
Contingencies at 10 percent	34,700
Total capital cost	381,300
Annualized capital cost at 10 years, 20 percent	90,900
Operation and maintenance	
Yeast and chemicals at $0.18 per gallon	1,100
Electricity at $0.06 per kwhr	900
Labor at $8 per hour	12,200
Maintenance at 6 percent of capital	19,600
Insurance at 1 percent of capital	3,300
Total operation and maintenance (ferment and distill)	37,100
Total annual cost	128,000
Cost per gallon (60,888 gallons) not including feedstock preparation	2.10

Table 4-4 Capital and Operation and Maintenance Cost for Alternative A-3

Cost component	Dollars
Capital	
Mobile refinery with natural gas boiler	0[a]
Operation and maintenance	
Electricity at $0.06 per kwhr	900
Labor at $8 per hour	12,000
Natural gas at $0.45 per therm	10,300
Processing fee from Parallel Products	36,500
Large boiler option	20,000[b]
Total operating and maintenance cost (ferment and distill)	79,900
Cost per gallon (60,888 gallons) not including feedstock preparation	1.31[c]

[a] All capital equipment is supplied by Parallel Products in this option.

[b] Only payable during first season of operation.

[c] The per gallon cost in the second year is $0.98.

the season, the alcohol production would be 6,240 gpd, which is within the 7,000-gpd capacity of Gibson's distillation tower. However, it is uncertain at this time whether Gibson would even want to process United Packing's DM. Assuming that the feedstock preparation capital cost will increase by a factor of 4, and operation and maintenance will multiply by eight, the processing cost for eight times the culls from the Sanger Plant is lowered to $0.67 per gallon. The total cost to United Packing is $1.87 per gallon for the finished product at 190 proof, not including sewer charges.

Byproduct Handling

Once the distillation of the DM is complete, the remaining mixture of water and solids (stillage) must be dealt with. There are three alternatives for ultimate disposal of the stillage: (1) discharge to the sewer, (2) land application, and (3) evaporation and drying for animal feed. Digestion of the stillage slops is an intermediate step to any of these disposal alternatives because once digestion is complete, the remaining slops still need disposal. All three disposal options plus digestion are discussed in this section.

Stillage Characteristics. Little data exists on the characterisitcs of fruit stillage, however, it is thought to be similar to winery stillage. Typically, stillage has a high total solids content (20,000 milligrams per liter (mg/l)); suspended solids of 13,000 mg/l; high chemical oxygen demand (COD) (20,000 mg/l); high biochemical oxygen demand (BOD_5) (10,000 mg/l), and low pH (3.7 to 4.7). Assuming 240 gallons of stillage per ton of culls, the average daily stillage flow ranges from 2,800 to 35,000 gpd with Sanger plant culls only.

Land Application. Land application of stillage is common in the winery industry. If certain minimum design criteria are followed, land application of stillage is an economic and environmentally safe method of disposal. Stillage is run into long narrow basins in a field to a depth of 3 to 4 inches. Each basin handles 1 day's flow. The basin is allowed to dry 7 to 12 days, then is disced. When a basin is dry, the cycle is repeated.

For the peak month of July, 35,000 gpd of stillage must be land applied. If a 4-inch and 7-day cycle is used, the total land area requirement for stillage disposal is 2.5 acres. This amount of land is owned by and readily available to United Packing adjacent to the Sanger plant. Therefore, no capital expenditures are required. The operation and maintenance cost associated with this system are insignificant because no increase in present farming costs for the land are required. The only requirement is periodic discing of the soil. This option has the added advantage of returning nutrients to the soil.

Sewer Disposal. This involves direct discharge (with possible precooling) to the sewer system. This would most likely be discouraged by the City of Sanger, however, it is unlikely they could prevent United Packing from discharging stillage to the sewers. A new tap to the sewer system would probably be required for a one time fee of $635. In addition, high monthly charges would be incurred. The monthly charges are based on flow and BOD_5 and suspended solids concentrations. They are calculated as follows:

$0.332 per 1,000 gallons times 1,826,000 gallons =	588
$0.012 per pound of BOD_5 times 152,300 pounds =	1,828
$0.031 per pound of suspended solids times 198,018 =	9,444
$15.80 per 1,000 gallons--peak day times 35,068 gallons =	554
$0.51 per pound BOD_5--peak day times 2,925 pounds =	1,492
$1.51 per pound of suspended solids--peak day times 3,802 pounds =	5,741
Total seasonal sewer charge	$19,647

If the fruit culls from seven additional packing sheds are processed, the sewer charges would be eight times $19,647 or $157,176 annually, which equals $0.32 per gallon in added cost.

Evaporation and Drying. No established markets exist at the present time for powdered fruit wastes as a protein supplement to cattlefeed. Making a powdered waste would involve evaporating the stillage in a multiple-effect evaporator to approximately 30 percent solids, then drum drying it to a powder consistency. The multiple effect evaporators require steam, and the dryer uses natural gas. Considering both capital and O&M expenses, it would cost approximately $0.011 per gallon of feed at 2 percent solids to produce the powder. At 240 gallons of stillage per ton, the cost is $2.69 per ton of culls to produce roughly 40 pounds of powder. This equals a production cost of $132 per ton of powder. The powder can probably be sold for $30 per ton or more if markets can be created. Based on the unattractive economics, evaporation and drying will not be considered any further.

Digestion. Digestion is not a true disposal option because the digested slops still must be disposed. However, it does have the advantage of producing a usable gas from the stillage while reducing the BOD_5 and COD. A commercially available upflow anaerobic digester is available from CSM Corporation, Holland. The unit is distributed by Joseph Oat Corporation, Camden, New Jersey. The estimated cost for a digester to handle ton stillage generated by processing 7,611 tons of culls per season is $300,000. The methane gas produced (1.75×10^9 Btus) is worth $7,875 at $4.50 per 10^6 Btus. The BOD_5 and COD reduction during digestion is approximately 70 percent. Neglecting O&M costs, the digester has a simple payback of 38 years. To digest the stillage from 60,900 tons of culls per season requires a capital investment of $1.5 million. The gas produced (13.02×10^9 Btus) is worth $59,000. Neglecting O&M costs, the digester has a payback of 25 years. The economics can be made slightly more attractive by using the digester to process Gibson Winery's stillage during the grape season. However, this still does not significantly change the economics. Therefore, digestion will not be considered any further.

ALCOHOL END USE

All of the alcohol production scenarios described will produce 190-proof ethanol which can be used in on-site energy production or sold as fuel.

On-Site Energy Production

Processing only the culls available at the Sanger plant produces an insufficient quantity of alcohol to provide energy independence from Pacific Gas and Electric (PGandE). If 60,900 gallons of 190-proof ethanol were available at a heating value of 80,750 Btus per gallon, approximately 360,000 kilowatts per hour (kwhr) could be generated. The percentage of the present monthly electrical usage then can be met by on-site electrical generation using 60,900 gallons of ethanol as shown in the following table.

Month	Percent of Monthly kwhr
May	100
June	100
July	77
August	87
September	87
October	100

As indicated in the table, the ethanol can provide a significant protection against electrical shortages, even during the peak packing months. However, to meet the total projected annual demand of 2,536,600 kwhr (with implementation of the energy conservation meaures (ECMs), see Table 2-5) and achieve energy independence would require 429,100 gallons of 190-proof ethanol. In order to produce this quantity, it would be necessary to obtain not only the United Packing culls, but also the culls from seven additional packing houses, and use Alternative B which requires the Gibson Winery facility. The total ethanol production of 489,000 gallons would satisfy the electrical demand.

Technical Issues. There are technical problems with burning straight alcohol in stationary engines. Conversations with the California Energy Commission revealed that they know of no stationary engine manufacturer in the United States whose engine can run on straight alcohol. However, two possible foreign manufacturers were mentioned by the Energy Commission: Komatso in Japan, and Mann in Germany. Further research indicated that these two foreign manufacturers were testing alcohol fuels in their mobile engines only. Although the technology for burning alcohol in the mobile engine sector is being developed, both in the United States and abroad, no stationary engines fueled with straight alcohol are known to be operating at this time. The key problem has been material compatibility. Alcohol is highly corrosive to standard carburetors, gas tanks, and elastomers, as indicated by the Waukesha Engine Division.

A recent report by the Department of Energy (DOE) identified several problems with alcohol fueled industrial engines.[1] Tests were conducted on John Deere, International Harvester, White, and Caterpillar diesel engines. Problems encountered were:

1. Reduced power output--only 80 horsepower (hp) out of a 120-hp engine with unburned alcohol in the exhaust.
2. Degradation of mild steel parts with 160-proof alcohol due to the water content.
3. Crankcase oil dilution.

The general conclusion of the report was that it is possible to run diesel engines on various proofs of alcohol, but durability over long periods of time has not been established.

In another study[2] better results were achieved when a small gasoline-fueled tractor engine was converted to operate on ethanol/ water solutions. It performed well with a slight increase in thermal efficiency and little change in power output using 80 to 100 percent ethanol.

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[1] Bartlesville Paper.

[2] ASAE.

In both the gasoline and diesel fueled engines, reliable long-term operation has not been proven. In addition, most work to date has been on small engines for vehicle use. Large alcohol fueled stationary engines are needed to meet the approximate 1,350-kw peak demand, and technology in this area has not been proven. More work is needed to overcome operating problems and to determine the best ethanol/water mixture for operation.

Sale as a Fuel

The 190-proof ethanol could also be sold to an anhydrous producer for use in gasohol. The exact cost to produce anhydrous alcohol is not precisely known. Katzan Association (1980) reported that the additional cost to produce 200 proof from 190 proof would range from $0.12 to $0.20 per gallon depending on the size of the facility. Raven Company has an anhydrous column for refining 190-proof alcohol. Including overhead and profit, and considering the small size of the facility, an additional cost of $0.30 per gallon to process to anhydrous alcohol seems reasonable if anhydrous is desired.

SUMMARY

A summary of the alcohol production cost per gallon (including new feedstock preparation equipment) and the disposal cost per gallon is presented in Table 4-5.

Clearly, the most economical means of producing ethanol from cull fruit at United Packing is with Alternative A-3 and land application of the stillage. The total cost is $1.62 per gallon. If credits are considered, the net cost of Alternative A-3 is $0.47 per gallon. It is obvious when comparing Alternative A-1 to A-2 that it does not pay to buy a biomass boiler. Also, a comparison of cost for A-3 and B to A-1 and A-2 indicate that it does not pay to purchase equipment. Therefore, United Packing should have Parallel Products supply the equipment and process only the culls available at Sanger. If more culls are available (i.e. eight times the Sanger culls), the Gibson Winery facilities could be used. It is important to remember that both the costs of A-3 and B are based on unconfirmed estimates for processing the culls. Also, the cost per gallon will increase as natural gas and labor rates increase.

Other potential uses for the ethanol in addition to its use as a fuel were identified and evaluated. They include sale as a wine fortifier or as a fruit brandy. These options are discussed in Appendix B.

Table 4-5 Total Cost of Alcohol Production, dollars

	Production alternative number				
	A-1 (60,900 gallons)	A-2 (60,900 gallons)	A-3 (60,900 gallons)	B (60,900 gallons)	B (487,100 gallons)
Cost per gallon for					
Feedstock preparation	1.03	1.03	0.31	1.03	0.67
Distillation	1.78	2.10	1.31	1.20	1.20
Land application of stillage	0[a]	0[a]	0[a]	N/A	N/A
Sewer discharge	N/A	N/A	N/A	.32	.32
Pit disposal[b]	0	0	0	0	0
Total, cost per gallon	2.81	3.13	1.62	2.55	2.19
Credits per gallon for					
Fuel use credit	<0.40>	<0.40>	<0.40>	<0.40>	<0.40>
Cull disposal[c]	<0.75>	<0.75>	<0.75>	<0.75>	<0.75>
Investment tax	–[d]	–[d]	N/A	–[d]	–[d]
Net cost per gallon	1.66	1.98	0.47	1.40	1.04

[a] Assumed to occur at no additional cost to current farming operations.

[b] Assumed to be no cost since a market exists for sale of pits.

[c] Based on avoided cost of $6 per ton for 7,610, tons of culls.

[d] Refer to Table 5-1 and 6-1 for details applicable to facilities.

CHAPTER 5

COGENERATION ALTERNATIVES

This chapter will identify and evaluate possible cogeneration schemes to work in conjunction with or independently of the alcohol production alternatives presented in Chapter 4. Because the Sanger plant lacks a major steam or other thermal energy demand, and a site survey of industries in the area also identified no possible steam markets, opportunities for true cogeneration are limited. A description of each alternative is presented, and a preliminary economic analysis is included for those technically sound alternatives.

Regulatory Aspects

In 1978, the United States Congress enacted into law the Public Utility Regulatory Policies Act (PURPA) which, among other actions, requires all utilities to purchase power from "qualifying facilities" at the utilities' avoided costs and exempts the qualified facilities from any federal or state rate making procedures. Qualifying facilities are cogeneration facilities utilizing natural gas or oil and small power producers using renewable resources for fuel.

Rules developed by the Federal Energy Regulatory Commission (FERC) define a cogeneration facility as equipment used to produce electrical energy and forms of useful thermal energy (heat or steam) through the sequential use of energy. There are two types of cogeneration facilities: (1) bottoming cycle where the energy input to the facility is first applied to a useful thermal energy process with the reject heat from the process being utilized to produce electricity and (2) topping cycle where the energy input is first used to produce electricity with the reject heat utilized for process use. The only cycle that has any applicability to the United Packing situation would be a topping cycle. In this case, the requirements for qualifying under PURPA are outlined on Figure 5-1 where natural gas or oil is used.

For renewable resources, such as alcohol from waste fruit or steam or gas from thermal processing of biomass, there are no efficiency requirements, and up to 25 percent natural gas or oil may be fired.

Power Production Alternatives

A brief description of each power production alternative considered for the Sanger plant follows. As mentioned earlier, because neither the Sanger plant nor any neighboring facilities

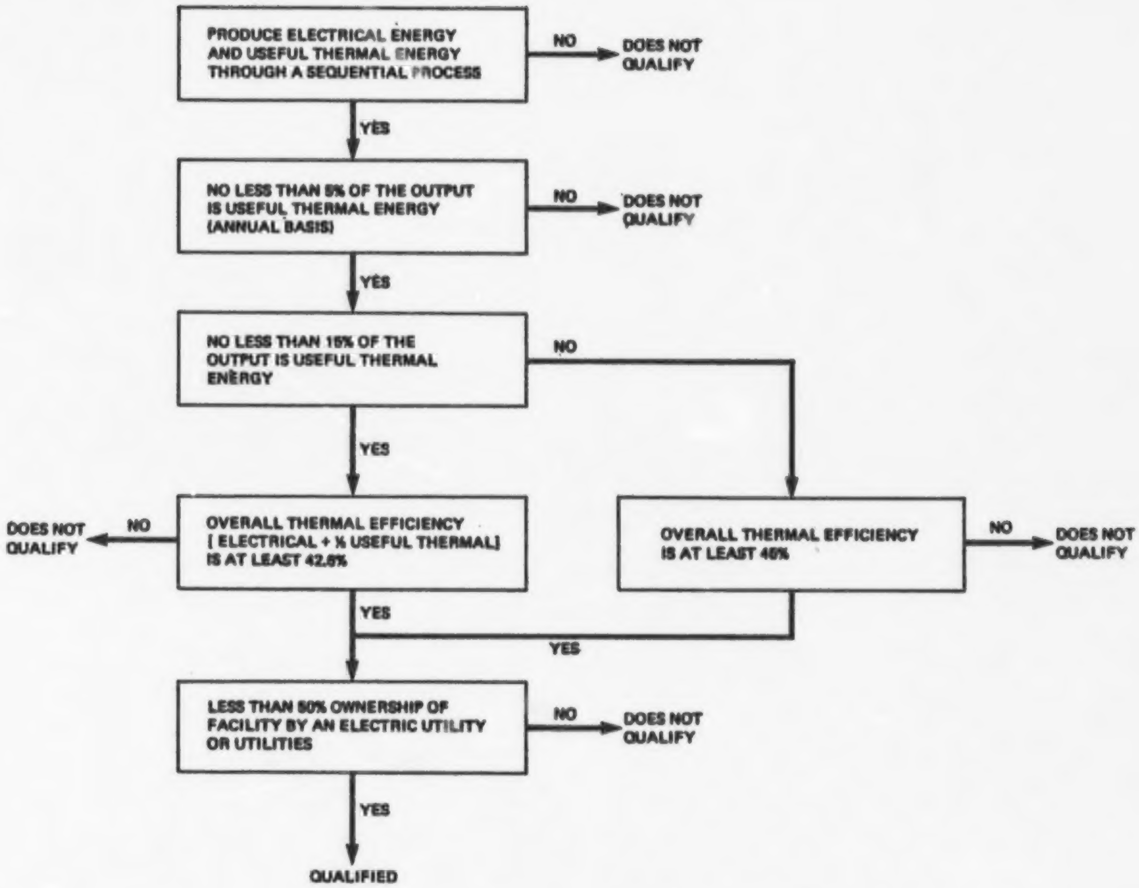
PRODUCE ELECTRICAL ENERGY AND USEFUL THERMAL ENERGY THROUGH A SEQUENTIAL PROCESS
NO
DOES NOT QUALIFY
YES
NO LESS THAN 5% OF THE OUTPUT IS USEFUL THERMAL ENERGY (ANNUAL BASIS)
NO
DOES NOT QUALIFY
YES
NO LESS THAN 15% OF THE OUTPUT IS USEFUL THERMAL ENERGY
NO
YES
DOES NOT QUALIFY
NO
OVERALL THERMAL EFFICIENCY [ELECTRICAL + ½ USEFUL THERMAL] IS AT LEAST 42.5%
OVERALL THERMAL EFFICIENCY IS AT LEAST 45%
NO
DOES NOT QUALIFY
YES
YES
LESS THAN 50% OWNERSHIP OF FACILITY BY AN ELECTRIC UTILITY OR UTILITIES
NO
DOES NOT QUALIFY
YES
QUALIFIED

Figure 5-1 Requirements for Qualification Under PURPA for a Topping Cycle Cogeneration Project

have a thermal energy demand, a true cogeneration project (as defined in the preceding section) is not possible. However, with the production of alcohol on-site, a maximum average demand of 72,000 British thermal units (Btus) per gallon of ethanol can be created. Modifying the refrigeration equipment (see Chapter 2) could also create an additional steam demand. However, based on capital cost alone (see Chapter 2), these modifications have been shown not to be economically attractive and therefore, are not considered as potential uses for steam.

No detailed financial or life-cycle cost analysis has been prepared for any alternative. This information will be presented in Chapter 6 for the selected project. The criterion of simple payback has been used. To calculate simple payback, the following equation was used:

$$\text{Payback} = \frac{\text{First Cost}}{\text{Annual Savings}}$$

First costs are the estimated installed costs of the various systems. In our analysis, no investment tax credits or energy tax credits are taken, although such credits are possible. Annual savings are estimated as the sum of avoided costs for energy demand and steam generation, plus revenues from energy sales to Pacific Gas and Electric Company (PGandE) where possible.

Also note that the analysis does not reflect anticipated fossil fuel increases which will affect avoided cost savings. A summary of the costs for each alternative is presented in Table 5-1.

Alternative 1. This alternative would meet all the electrical needs of the Sanger plant (about 2.5 x 10^6 kilowatt-hour (kwhr) per year) using diesel engines converted to run on ethanol as prime movers to generate 1,350 kilowatts (kw) of electricity. For reliability, we have assumed three 750 kw-engine generator sets. One or two engines would operate continuously to meet all of the plants annual electrical demands, with one engine serving as a standby. A steam credit is given for waste heat recovery to produce steam for distillation.

Lacking any better data, we have assumed for the purpose of estimating costs, that capital costs of diesel engines converted to run on ethanol are identical to diesel-fueled engines.

Alternative 2. A 20-MW, steam-cycle, electrical-generating system fired by biomass is used in this alternative. This system would require about 20 tons per hour of biomass. Since no collection, transportation, or processing system exists, such a system would have to be developed as a part of this project. The fuel would be fired in a spreader stoker boiler. Sufficient

Table 5-1 Summary of Preliminary Economics for Power Production dollars

	Alternative					
	1	2	3	4	5	8
Total installed cost	1,550,000	32,450,000	9,100,000	1,790,000	2,790,000	680,000
Annual operating costs						
Fuel cost	352,000[a]	500,000	100,000	28,600[b]	352,000[a]	28,600[b]
O&M[c]	150,000	3,250,000	900,000	5,000	175,000	5,000
Total, operating costs	502,000	3,750,000	1,000,000	33,600	527,000	33,600
Annual energy savings						
Electrical savings[d]	209,000	209,000	209,000	21,600	209,000	21,600
Steam credits	83,000	0	0	0	83,000	0
Electrical sales	27,400	8,227,000	1,923,400	0	27,400	0
Total, savings	319,400	8,436,000	2,132,400	21,600	319,400	21,600
Net annual operating cost or (saving)	265,600	(4,686,000)	(1,132,400)	12,000	207,600	12,000
Simple payback period, years	-	7.0	8.3	-	-	-
Net annual cost[e]	635,000	3,054,000	1,038,000	439,000	873,000	174,000
Cost per kWh	0.25[f]	0.11[g]	0.12[g]	1.22[h]	0.35[f]	0.48[h]

[a] Ethanol at $0.72 per gallon.

[b] Ethanol at $0.47 per gallon.

[c] Includes operation and maintenance labor, and maintenance materials.

[d] Based on projected electrical cost for year ending March 1982.

[e] Includes annualized installed cost, based on 20 percent, 10 years.

[f] First year cost without escalation for 2.5 x 106 kWh plant use.

[g] First year cost without escalation for all generated power.

[h] First year cost without escalation for 360,000 kWh standby.

amounts of steam would be available for any size alcohol production system. Since the fuel source is biomass, meeting PURPA regulations is not a concern. The major advantage of this system is large revenues from electricity sales.

A 20-MW facility has been selected since studies show that this size is more economical than smaller facilities. Supplies of biomass fuel within a 50-mile radius of United Packing are thought to be adequate at this time to fuel a plant this size, even if there are one or two major competing projects in the area. In addition, municipal solid waste may become usable in this alternative. The costs presented in Table 5-1 included collection, transportation, and processing equipment.

Alternative 3. This alternative is identical to Alternative 2 except the size of the facility is reduced to 5 MW. This alternative has a much lower initial cost than Alternative 2 and only a slightly longer payback period.

Alternative 4. Under this alternative, ethanol (produced by any method described in Chapter 4) is burned in a gas turbine to produce electricity. Part of the annual electrical need for a month or several months (depending on the time of year) can be met with this alternative. If 60,900 gallons per year are burned, then 360,000 kwhr can be produced (at a savings of $21,600), which is only 12 percent of the annual requirement. No steam credit is included; waste heat recovery equipment cost cannot be justified for standby equipment. The lowest cost of the ethanol is assumed to be $0.47 per gallon. There are a number of possible technical issues to be resolved in the fueling of gas turbines with alcohol. Although technically feasible, to our knowledge alcohol fueled gas turbines have not been adequately demonstrated on a long-term basis.

Alternative 5. This alternative is identical to Alternative 4 except eight times the amount of ethanol is presumed available (487,000 gallons per year). Because of the large quantity of ethanol, the cost per gallon of $1.04 has been used. This is equal to the $2.19 gallon presented for alcohol production Alternative B, less the tax credit and cull disposal credit. A credit is given for waste heat recovered to produce steam for alcohol distillation. All the ethanol is burned in gas turbines to meet plant electrical needs, with any excess electricity being sold to PGandE. With this amount of alcohol, the total annual plant needs can be met (2.5×10^6 kwhr per year) and excess power would be sold (342,000 kwhr per year).

Alternative 6. The production of fuel gas from agricultural residue by pyrolysis or thermal gasification is a potentially attractive alternative. Brown and Caldwell has done a detailed evaluation of over 25 different hardware systems that utilize biomass and wastes as a feedstock. These systems are in various stages of development. Brown and Caldwell has conducted tests and prepared detailed evaluations of four systems. All systems appear to be insufficiently developed to justify further consideration by United Packing at this time. The minimum cost of producing gas in this manner is estimated to be in the range of $10 to $15 per 10^6 Btus, therefore, a cost breakdown has not been included in Table 5-1.

Alternative 7. Anaerobic digestion of fruit to produce methane is a technically feasible process if the scale of operation is sizable and feedstocks are available the year around. However, we have rejected this approach due to high capital costs and a very long payback period (see Chapter 4).

Alternative 8. The equipment is similar to that described for Alternative 1 except the engine generator sets are lighter duty because they only need to provide standby power. Production and use of 60,900 gallons per year of ethanol under this alternative would provide significant protection against power utility failures.

Conclusions

Alternatives 1 through 5 would provide complete energy independence from PGandE. However, only Alternatives 2 and 3, biomass-fired steam cycle electrical generation, have payback periods which may be acceptable. Both require large capital expenditures and detailed economic analysis beyond the scope of this study before any decisions could be made. It appears that energy independence from PGandE using alcohol as a power source cannot be achieved economically. However, it appears feasible using a biomass fueled power plant. This requires a large capital expenditure and a 7- to 8-year payback period.

The alternative which requires the least capital is Alternative 8, standby power generation. Although this will not provide energy self sufficiency for United Packing, it will provide assurance against power shortages of 3 weeks or more. In the calculations shown, it also has the least annual loss. This loss must be recalculated by United Packing in light of their tax status, cost of capital, and the impacts of investment tax credit (10 percent), energy tax credits (10 percent), and depreciation. Net loss (if any) does not mean much in this case because the loss figure is the price paid for the certainty of an electrical supply. The potential loss that might be incurred due to power shortages must be compared to the total annual cost of this alternative. In addition, this alternative must be viewed in the overall context of the project including the alcohol production alternatives. This will be discussed in Chapter 6. Alternatives for supplying power with fossil fuel are discussed in Appendix B.

CHAPTER 6

PROJECT SELECTION

Information from Chapters 2, 3, and 5 is combined into an overall energy program for United Packing's Sanger plant which makes use of the alcohol produced from the cull fruit. A project description and system economics are presented in the following sections.

Project Description

The recommended project includes three separate steps: (1) implementation of the recommended energy conservation measure (ECMs) outlined in Chapter 2, (2) on-site production of ethanol using only culls available at the Sanger plant, and (3) installation of a ethanol-fueled stand-by power supply. Each of these steps are discussed below.

Implementation of Energy Conservation Measures. The energy analysis presented in Chapter 2 indicates that certain ECMs should be implemented immediately, regardless of what other steps of this project are followed. These modifications will pay for themselves in less than one season. A number of secondary ECMs are also described although not recommended for immediate implementation. These ECMs should be reviewed on a regular basis and action taken when increased energy prices make them cost effective.

Alcohol Production. For the 1982 packing season, alcohol should be produced from the culls available at the Sanger plant. United Packing should contract with Parallel Products to process the culls on site to 190 proof ethanol as described in A-3 for an estimated total cost of $0.47 per gallon (including credits). Negotiations between United Packing and Parallel Products to establish a firm price, warranty, and scope of services should begin immediately. Among the points which must be clarified during negotiations are (1) who will provide the feedstock preparation equipment, (2) who must obtain the necessary permits from the Treasury Department, and (3) the timing of equipment delivery. Design of any special equipment interfacing must also be considered so the necessary modifications to plant equipment can be made this winter. Production of alcohol from fruit culls will reduce the culls being landfilled by about 90 percent. This translates to 6,850 tons per season for the Sanger plant.

Obtaining the equipment from Parallel Products for the packing season will enable United Packing to commit only minimal, if any, capital investment in the alcohol equipment. United Packing has a season to gain experience with the alcohol production system and time to develop additional sources for cull fruit. If, after a season of operation, United Packing decides to abandon the alcohol business or change its processing approach (i.e., go with larger quantities at Gibson or elsewhere), this can be done quite easily by foregoing subsequent leases.

A soil amendment program should be implemented as part of the alcohol production system. There is sufficient land adjacent to the Sanger plant where the stillage can be land applied as a soil amendment. This system has the advantages of minimal capital investment, environmentally sound by-product management, and an increase in the quality of marginal soils.

Installation of Standby Power. Installation of standby power was selected from the alternatives covered in Table 5-1 because it is the most cost-effective use of the alcohol. It has the lowest capital investment and the smallest annual cost for the installation of an ethanol-fueled standby power facility. It would consist of either converted diesel or gasoline engine generators and fuel storage tanks as described in Alternative 8 in Chapter 5. Although this system is not conceived to provide total energy independence from Pacific Gas and Electric Company (PGandE), it has minimal risk and will provide assurance against power shortages of 3 weeks or more.

The installation of standby power also minimizes the risk associated with the stage of developmment of alcohol-fueled stationary engines. Experience can be gained with this new technology and as the technology is refined, a decision to use alcohol-fueled engines as prime movers at the Sanger plant in later years can be based on personnel experience and improvements in state of the art.

If a suitable ethanol-fueled standby power supply cannot be on line by the 1982 season, plans should proceed to produce ethanol anyway. The alcohol produced in the 1982 season could be sold as a fuel. The alcohol could either be sold for direct use in light duty engines (i.e., to on-farm equipment or fleet vehicles in the CEC program) or to a processor for further refinement to anhydrous for ultimate use in gasohol. Under the right conditions, sale for direct use in vehicles would allow United Packing to take a $0.40 per gallon tax credit. In any case, a market contract is essential to the feasibility of the alochol project. United Packing should have contracts for the purchase of this alcohol before the project is implemented. A detailed market investigation (i.e., names of buyers, etc.) is beyond the scope of this study.

If United Packing desires to be totally self-sufficient, biomass fueled power plants in the range of 5 to 20 MW appear feasible based on the preliminary evaluation in Chapter 5. A decision to proceed in this manner would require a detailed study which is beyond the scope of this report. This option, although requiring large capital outlays and potential fuel supply problems, could be very attractive with large escalations in energy prices and should be reevaluated in the future on a regular basis.

Once such an initial capital investment is made, the project operating and maintenance costs remain relatively insensitive to escalating energy prices. However, project revenues will increase making the payback period shorter.

Project Economics

A breakdown of the capital and operating and maintenance costs associated with implementation of recommended alcohol production and standby power project steps is presented in Table 6-1.

The capital costs are presented with the appropriate tax credits. Note that an income tax credit has been included to alcohol production. This credit is available if the alcohol is used or sold for direct use as a fuel. However, it is not certain that United Packing would be able to take this credit if the alcohol was sold for further refinement of anhydrous and blending to gasohol. This point must be clarified by the IRS. Also, $45,700 has been credited to the alcohol production for the savings in disposal costs of the culls. To facilitate equipment interfacing, $12,000 has been included under alcohol production capital costs for minor plant modifications. It assumes all feedstock preparation equipment is provided by Parallel Products.

The annual saving generated by the project is $23,000 (due to the ECMs), the required capital outlay is about $629,000. This yields a payback of about 27 years. The payback is due entirely to the implementation of the ECMs. The project would never pay for itself if only the installation of standby power fueled by alcohol is considered. However, for assurance against loss of power, installation of the standby engine generators is necessary and provides the most economic on-site use for the ethanol.

Off-site uses for the ethanol are discussed in Appendix B, in addition to power production alternatives involving fossil fuels.

Table 6-1 Cost of the Recommended Project for Alcohol Production and Energy Generation

Cost component[a]	Item			
	Energy conservation measures, dollars	Alcohol production, dollars	Standby power supply, dollars	Total, dollars
Capital				
Construction cost	9,300	12,000	680,000	701,300
Investment tax credit[b]	(930)	(1,200)	(68,000)	(70,130)
Energy tax credit[b]	(930)	(1,200)	0	(2,130)
Net capital cost	7,440	9,600	612,000	629,040
Annual cost or (revenue)				
Annual O&M	0	28,600[c]	5,000[d]	33,600
Energy savings[e]	(23,300)	0	(21,600)	(44,900)
First year net cost[f] (saving)	(15,860)[g]	31,500	145,600	161,240

[a] All cost in June 1981 dollars. For a detailed breakdown refer to Chapters 2, 4, and 5.

[b] 10 percent of capital cost.

[c] Includes all credits. See Table 4-4, based on 60,900 gallons per year at $0.47 per gallon.

[d] Excluding fuel cost.

[e] Based on $0.06 per kwhr.

[f] Including amortized capital at 20 percent, 10 years.

[g] Amortization not applied because payback is less than 1 year.

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1. Cruz, J.M., Swarr, H., Rotz, C.A., Wilkinson, R.H. Engine Conversions for Alcohol Fuels. American Society of Agricultural Engineering. Paper Number 81-1052. June 21-24, 1981.

2. Clingenpeel, James M. Evaluation of Alcohol in Diesel Engines in Farm Applications. U.S. Department of Energy, Bartlesville Energy Technology Center, Bartlesville, Oklahoma. In Proceedings of Regional Workshop on Alcohol and Vegetable Oil as Alternative Fuels. Sacramento, California. April 21-23, 1981.

APPENDIX A

EQUIPMENT INFORMATION

the national energy™ solution

NATIONAL ENERGY
SOLUTION 100
OFF
STATUS
OFF
KEYBOARD
ON
BATTERY

logical
simple
affordable

A-2

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best available copy.

ENERGY MANAGEMENT....

logical affordable

Confused about Energy Management, available systems, installations, operation and cost? Understandable.

The Truth is, there is *one* system that eliminates ALL the confusion. By *Simply* creating a *Logical* program around facility operating schedule, environmental requirements and utility rate structures, the NATIONAL ENERGY™ **SOLUTION 100** will control all environmental loads, reduce energy consumption and electrical demand, and put the savings in YOUR pocket, automatically.

In addition, NATIONAL ENERGY™ eliminates the need to run miles upon miles of wire — sometimes an impossible task!

SIMPLE INSTALLATION = REDUCED COSTS

The NATIONAL ENERGY™ **SOLUTION 100** sends coded, digital impulses through the existing AC wiring to NATIONAL ENERGY™ TeleSwitches, where the signal is received, "de-coded" and the necessary switching takes place, automatically.

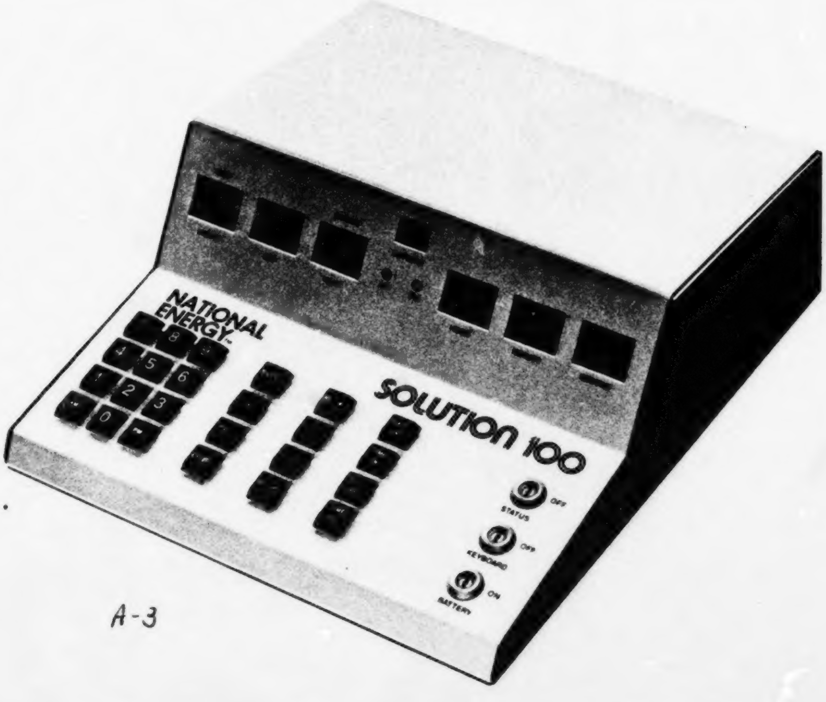
Eliminates Energy Waste

Reduces Electrical Demand

simple

Easy to Program
Easy to Install
Easy to Understand

The NATIONAL ENERGY™ **SOLUTION 100** *is the* Most Optimum Dollar Per Load *buy in Energy Management today!*



....LOGICALLY SIMPLE

features

Plugs into Any 110v AC Outlet

- Simplicity
- Program Flexibility
- Attractive
- User Programable
- Automatic Overrides
- Manual Overrides
- 7-Day Advance Programming
- 100 Year Calendar
- Rechargeable Battery
- Lock-out Keyboard

capabilities

- Accepts up to 83 different programs
- Manual control of 100 control points
- No limit on total control points
- Night and Weekend Set-back, forward
- Indoor/Outdoor Lighting Control
- Load Cycling
- Duty Cycling/Sub Cycling
- Forced Demand Limiting
- Load Scheduling
- Process Control, Materials Handling
- Irrigation Control
- Activate Security Systems, Automatically

TOTAL BUILDING AUTOMATION

benefits

- Eliminates need for Hard Wiring to Control Points
- Low Installation Costs
- Tax Benefits:
  Qualifies Investment Credit,
  Energy Property Credit
- Solid State Reliability
- Reduces Demand $$
- Reduces Energy Consumption $$
- Total Control from Central Location

2-yr. Warranty*

* Conditions available from factory

SOLUTION 100 System Specifications

Computer

Input Voltage Requirements:	110/120 VAC 60 Hz.
Power Consumption:	20 Watts display on: 10 Watts display off.
Battery Operating Time:	Up to 10 hours
Battery Voltage:	12 VDC
Battery Rating:	4.5 Ah @ 10 hour rate
Power Consumption: (Internal D.C.):	Logic 440 MA, Display 400 MA Battery charging current 200 MA
Operational Temperature Range:	35° - 140° F.
Operational Humidity Range:	10% - 90% Non-condensing
Operating Frequency:	262 KHz
Keyed Switches:	Keyboard On/Off, Battery On/Off, Transmission On/Off
Meter:	Battery charge indicator
Weight:	10 pounds
Dimensions:	11" x 13⅜" x 4¾"
Program Storage:	83 User Programs* Control Program 2,045 bytes User Program 2,045 bytes
Device Coding:	Up to 100 unique points

*Programs can control 83 different loads or give multiple commands to any number of loads.

TeleGain Amplifiers

Amplifiers are available in two orders of magnitude. Installation is easily accomplished by simply plugging the TeleGain$_{TM}$ Amplifier into a 110/120 VAC outlet and plugging the **SOLUTION 100** into the amplifier.

TG-1

Input:	**SOLUTION 100** Computer Line Plug
Output:	Plugs into 110/120 VAC, 60 Hz, receptacle
Operating Frequency:	262 KHz
Impedence Matching Capability:	10 Ω to 35 Ω

STG-1

Input:	**SOLUTION 100** Computer Line Plug
Output:	Plugs into 110/120 VAC, 60 Hz, receptacle
Operating Frequency:	262 KHz
Impedence Matching Capability:	Less than 1 Ω and up

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TeleSwitches

The N.E.C. series of remote receiver/switches, TeleSwitches, allow for the switching of loads from 24v. to 480 VAC, single or three phase. TeleSwitches require from 110 VAC to 480 VAC, depending on model, to energize independent of load to be switched. Custom Panels, ie, multiple load switching, lighting control, are available from the factory.

The TeleSwitches pick up a digital signal from the **SOLUTION 100**, transmitted through the existing AC wiring, decode the signal and perform the necessary switching. Each TeleSwitch can accept up to 83 programs and can be coded 1 of 100 different codes.

All TeleSwitches are equipped with contact terminal points for both on and off automatic overrides. Automatic overrides may be any closure, ie, thermostatic, amperage, pressure, photoelectric, etc. TeleSwitches are also equipped with a manual override switch — on/auto/off.

TS-1

Maximum Loads:	208-480 VAC, Single/Three Phase, 40 Amp. per pole FLA, 50 Amp per pole RLA
Energizing Voltage:	110/120 VAC
Dimensions:	10" x 12" x 4"

TS-2

The TS-2 TeleSwitch is equipped with a three-prong plug for plug-in use into a 110/120 VAC outlet. Plugs may be removed for hard-wire, in-line installation.

Maximum Loads:	24v.-240 VAC @ 10 Amp.
Energizing Voltage:	110/120 VAC
Dimensions:	3½" x 9" x 2½"

TS-208

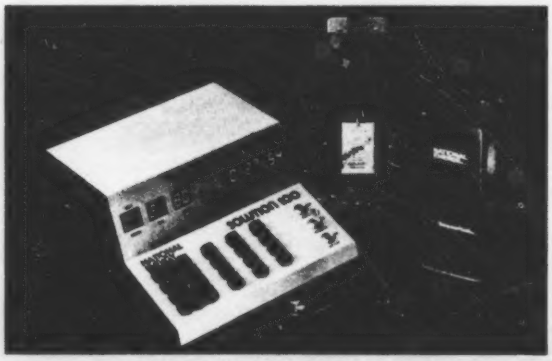
Maximum Loads:	24v.-240 VAC @ 10 Amp.
Energizing Voltage:	208/230/460 VAC, 3 ϕ
Dimensions:	10" x 12" x 4"

TS-480

Maximum Loads:	24v.-240 VAC @ 10 Amp.
Energizing Voltage:	220/230/240/460/480 VAC, 3 ϕ
Dimensions:	10" x 12" x 4"

Transformer By-Pass / Couplings

The N.E.C. series of transformer by-pass/couplings allow for signal communication across multiple phases of power, around transformers, and coupling of multiple electrical services. Refer to TBP Application Manual for proper coupling diagnosis and catalogue numbers.



SOLUTION 100 and TS-2's

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Thank you for your inquiry into the State-of-the-Art in Wireless controls from National Energy.

For more information, contact the National Energy sales representative listed below, or return the enclosed REPLY CARD. If no sales representative is listed, or if your needs are immediate, please call us at (802) 658-6445 and say, "I'd like to know more about INSTANT AUTOMATION!"

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WANLASS TECHNOLOGIES INCORPORATED

Introducing the first breakthrough in
electric motor technology
in over 100 years

A-7

WHAT IS ELECTRIC MOTOR EFFICIENCY?

No electrical motor is perfect. Due to inherent losses within the motor some percentage of the electricity you pay for is lost. These losses are:

1) Core Losses
2) Stator I^2 R Losses
3) Rotor I^2 R Losses
4) Friction and Winding Losses
5) Stray Load Losses

WHAT DOES THIS MEAN TO ME?

Due to the inefficiency of an electric motor the energy a motor delivers is only a percentage of the amount of energy it consumes. You are paying dearly for these losses.

Electrical motors consume 64% of all the electrical energy generated in United States. If you are responsible for saving energy then you owe it to yourself and your company to examine what the Wanlass motor can do to reduce your electric bill.

A recent study determined that increased cost for more efficient motors is more than justified. The study revealed that when energy savings are considered over the nominal life of the motor, just one percentage point increase in efficiency will justify a premium of more than 26% on the price of the motor. The Wanlass motor has shown that 10% to 40% savings on your electrical bill can be realized depending upon size, load and application of the motor.

Wanlass Technologies guarantees we will reduce the power losses in any 3 phase induction electric motor by at least 50% after conversion to the Wanlass method. This guarantee applies to motors 15 H.P. and above. Below 15 H.P. the reduction in losses may be somewhat less.

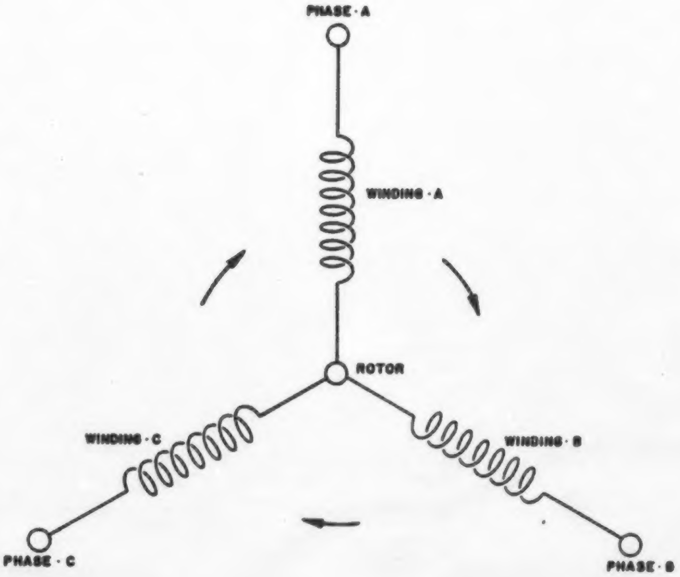
LOWER BILLING DEMAND

Your electric bill may be computed on a "Kw Demand" basis: The higher your "DEMAND," the greater your unit cost per Kilowatt hour. Therefore, the "Wanlass Motor" not only reduces the total number of Kilowatt hours consumed per month, but also lowers your unit cost for the kilowatt hours you use in all of your electrical apparatus.

WHAT CAN WANLASS DO FOR YOU?

1 - Modify your existing motors.
Authorized Wanlass repair shops will repair and modify your existing motors right in your area.

2 - Supply you with new Wanlass motors.
A new modern motor facility is located in Anaheim, California.



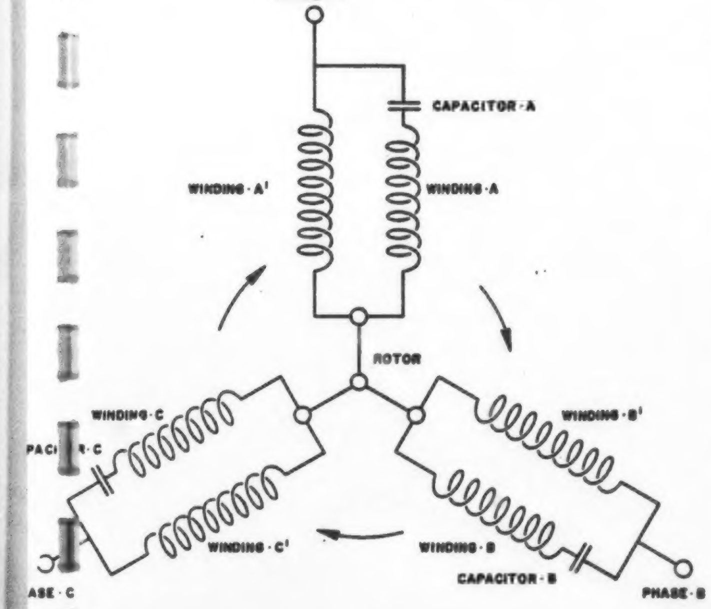
STANDARD INDUCTION MOTOR

HOW DOES THE WANLASS MOTOR WORK?

The main winding and associated capacitor provide a constant value of current that is in phase with the internal voltage. The control winding provides automatically without switching equipment or electronics a variable amount of current that is determined by the load condition of the motor.

The control winding generates current back into the system at light loads, has zero current at about 70% of load, and acts as a motor winding at loads above 70% of rating. With this type of operation power input to the motor is regulated proportionally to power output.

The capacitor and winding arrangement act further to increase the average magnetic flux density in the stator core while reducing the peak flux density. This has the effect of increasing the torque of the motor while reducing the core loss. The capacitor and winding arrangement also cause the motor to operate at unity power factor over a wide range of load.



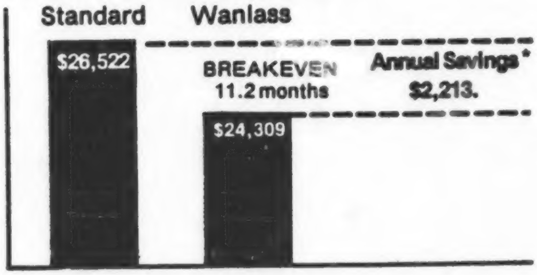
WHAT'S MY PAYBACK?

The biggest attraction of this type of investment is that payback comes directly from dollars you now spend on monthly energy bills. After the payback period is reached the savings are all yours!

EXAMPLE NO. 1: NEW MOTOR

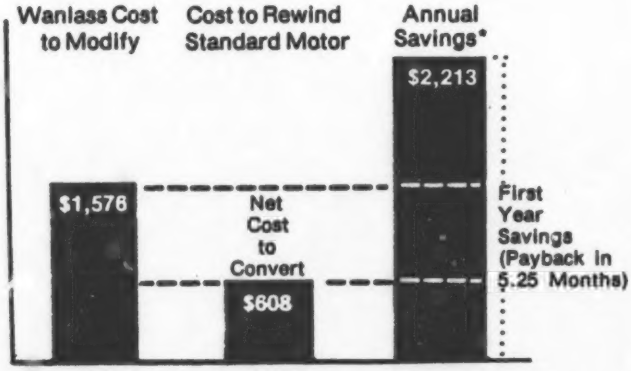
New Wanlass 50 H.P. motor versus a new standard motor. (Assume $.06 per KWh.) For open drip proof.

ANNUAL OPERATING COSTS

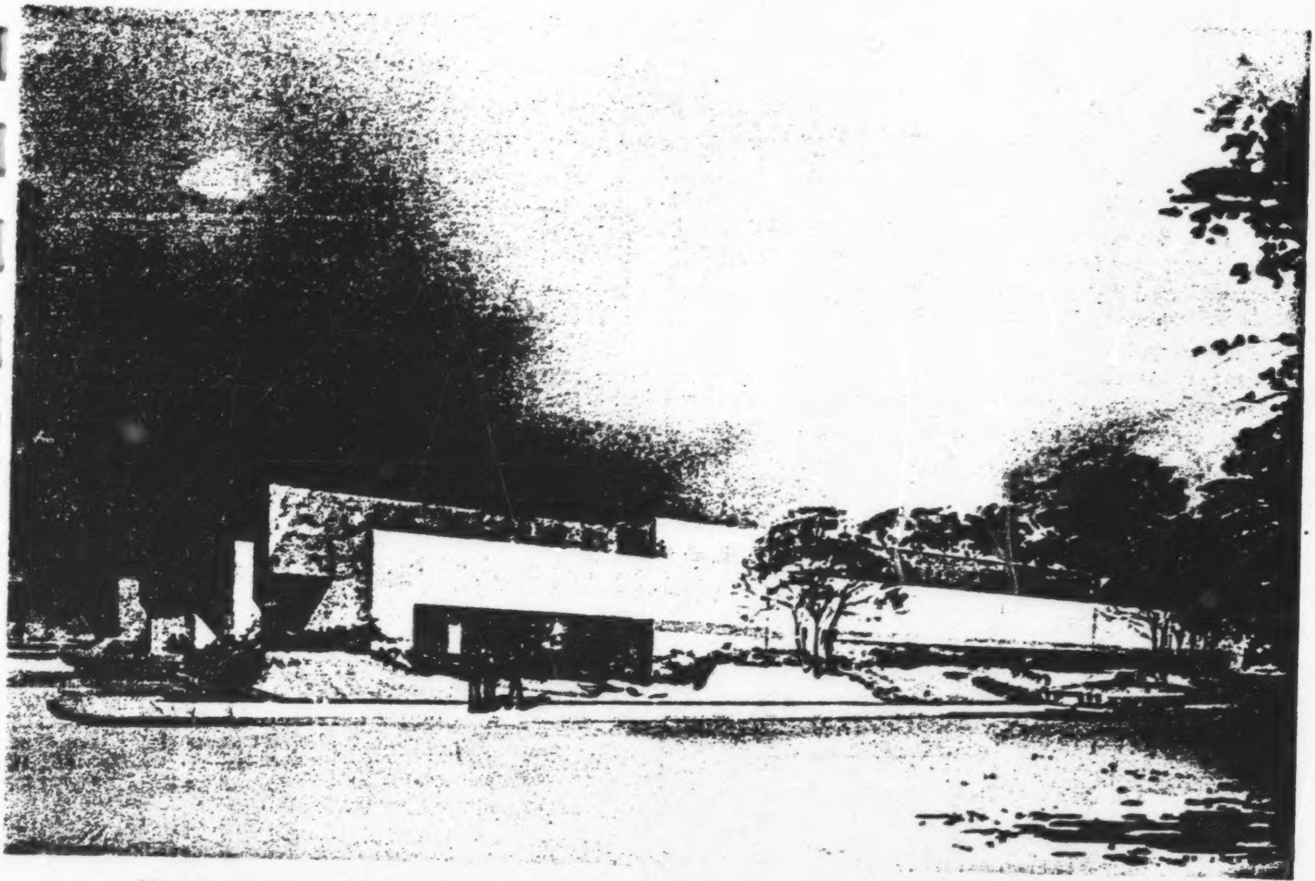


EXAMPLE NO. 2: MODIFY EXISTING MOTOR

Modify your existing 50 H.P. motor to the Wanlass method versus rewinding your standard motor using the conventional method.



*Note: Savings may vary slightly depending on energy rates and local rewind costs.



Wanlass new ultra-modern facility for new and modified electric motors.

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731-5277

A-10

MOBILE ALCOHOL REFINERY DESCRIPTION

Parallel Products mobile alcohol refinery is intended to convert sugar from liquid substrates to ethyl alcohol. Actual production must vary with the quality of the fermentation material (FM). Production rates of forty to one hundred gallons per hour can be expected, accompanied by nine hundred to fifteen hundred gallons per hour of liquid stillage by-product. The plant provides both fermentation and distillation in one vehicle which is easily moved and set up. Each unit can provide its own electric power, process heat, liquid handling and semi-automatic process controls.

Substrates for fermentation may be agricultural or food industry wastes or may be derived from special crops (such as artichokes or sugar cane) grown for fuel. Solid residues from such crops are excellent feeds, and methane from manure can be used to power the on-plant boiler. Through its associated engineering and fabricating firms, Parallel Products can provide services needed by the alcohol producer for substrate preparation. This preparation equipment can have a host of valuable applications for the farmer or food producer when they are not in use for fuel production. The use of mobile refining allows the potential fuel producer to put his investment into the preparation site rather than the less flexible refining equipment, which usually cannot be used year round.

Each plant is constructed on two semitrailers provided with a dolly for easy location. One trailer carries the column still, power and heat. The other carries the fermenter.

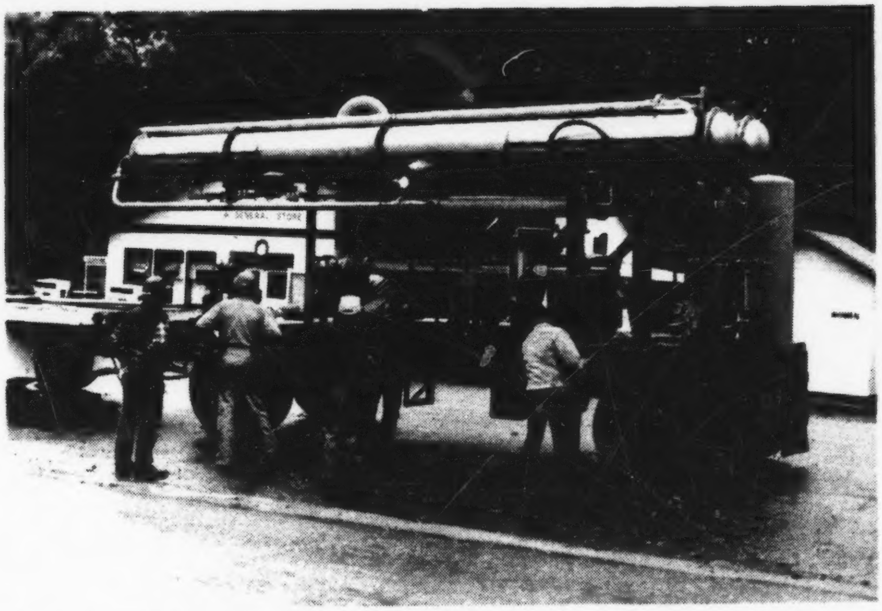
Dual stainless steel columns are used for distillation. Each column has twenty stainless sieve trays sealed at the column wall with teflon rings. Preheated distillation material (DM) enters the first column, or stripper, near the top, infiltration downward through segmental downcomers and across the trays. Low pressure steam moves up through the tray perforations. Alcohol vapor from this process passes through a stainless vapor line to the bottom of the second column or rectifier. The rectifier trays have smaller perforations to prevent weeping at a lower vapor flow rate. Slops and reflux from the product train pass down through tubular downcomers and are refluxed to the stripper via a metered case drain. Vapors at the rectifier head are normally of the desired product proof. These pass to the condenser to be cooled to liquid by the incoming DM. A proof hydrometer at the reflux drum controls a select valve sending product to the surge tank and lower-proof material back to the rectifier.

The controls are centrally located near the column base, reflux drum, and stillage drain. All critical liquid levels and temperatures are readily visible to the operator, as well as the actual appearance of the product and stillage. Large dial thermometers at the column base show the temperature of the rectifier overhead, stripper stillage and trays. Electrical controls are centralized nearby in a liquid-tight housing. Full view rotameters show the flow rates of the DM and product reflux. Precision flow controllers for process flows are located near the electrical panel.

Wiring is enclosed in liquid-tight conduit. Current is provided by an on-board power plant, or can be drawn from the grid or other source of 220 volt single phase AC. Units are provided with lighting for night operation.

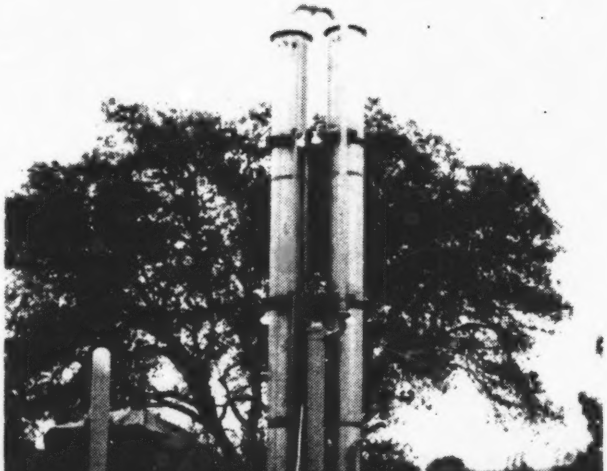
DM is produced in a continuous-flow vessel based on a design by Emil Wick. Continuous flow cells bring fermentation to near completion at a very high rate of conversion. This material moves to a larger capacity vessel for finishing. Flow controllers match the production of DM to the production rate of the distillation process.

A Burnham 55 BHP packaged boiler is used on the distillation plant. The boiler has its own automatic probe controls, linked to the plant control system. A Ray multi fuel burner is used to allow a variety of locally available fuels to be employed for steam, including ethanol products from the primary process. An auxiliary steam inlet is provided for locations where steam is available.

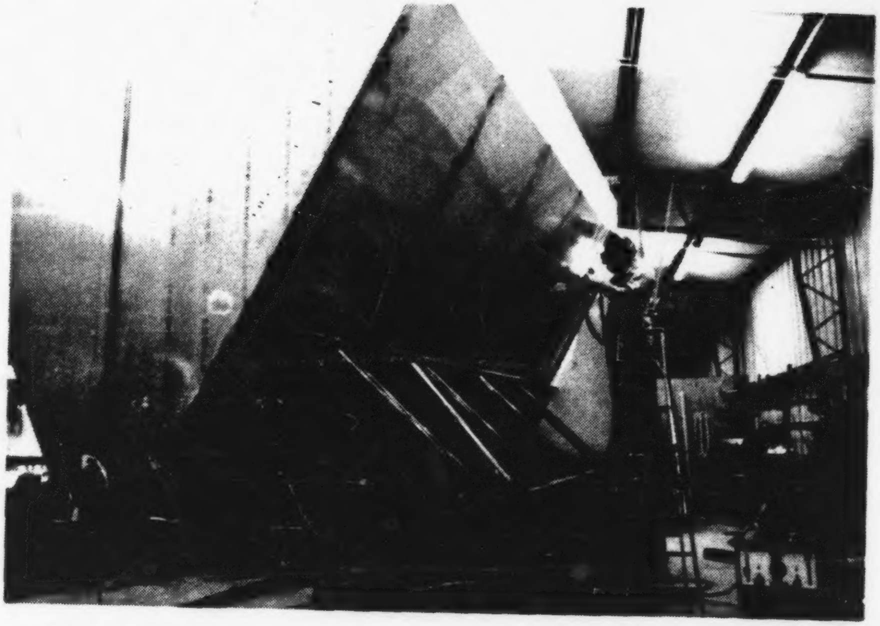


Mobile distiller in transport position.

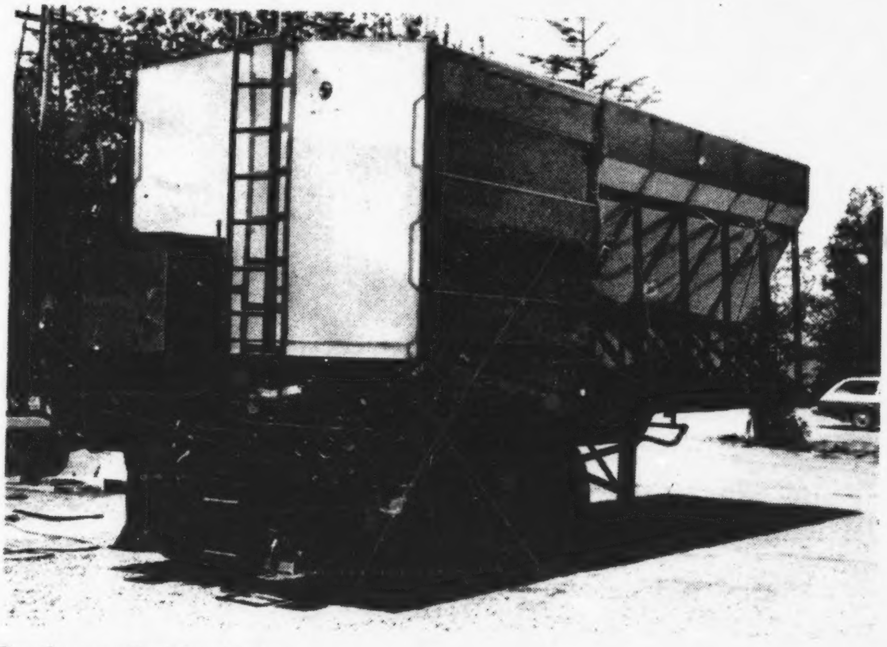
Distillation column being raised into operating position.



Distillating column in operating position.



Continuous flow fermenter under construction.



Continuous flow fermenter.

APPENDIX B

ALTERNATIVE ETHANOL USES

APPENDIX B

ALTERNATIVE ETHANOL USES

Uses of the ethanol for other than power production may prove to be economically attractive if firm markets can be established. The uses include sale as a wine fortifier and sale as a brandy.

Sale as a Wine Fortifier

High-proof alcohol (190 proof) is commonly used in the wine industry to fortify wines. Grapes which are picked early for their flavor often lack enough sugar to produce a high alcohol content. Therefore, alcohol must be added. The law states that only fruit alcohol can be used, not grain alcohol, so good fruit alcohol sells for a premium price. Today's price for high-proof alcohol for fortifying wine ranges from $1.50 to $2.00 per proof gallon. A proof gallon is 100 proof. Therefore, 190 proof is worth $2.85 to $3.80 per gallon.

Sale as a Brandy

If the alcohol from the culls meets certain industry standards, a market exists for brandy. Brandy is often made from rotten raisins, so chances are good that brandy from the fruit culls will also be saleable. The peaches, plums, and nectarines may have to be processed separately so the brandy can remain identifiable. It is not known whether the fruit may be combined and processed to yield "fruit brandy." In any case, the price for raw brandy is $5.00 per proof gallon or $7.60 per gallon of 190-proof brandy. If the alcohol fails to meet brandy standards, it can always be sold as a wine fortifier.

Alternative Conclusion

The total net cost per gallon for the production of ethanol is $0.47 from Table 4-5. Compared to diesel fuel at approximately $1.50 per gallon, the alcohol appears to save $1.03 per gallon of fuel used for standby power. However, the British thermal unit (Btu) content of diesel fuel is 142,000 Btus per gallon and for ethanol only 84,400 Btus per gallon. Therefore, on an equivalent Btu basis, the ethanol actually costs $0.79 per gallon. This amounts to a savings of $0.71 per gallon if ethanol is used as a fuel.

However, the alcohol is much more valuable as a brandy or a wine fortifier if a market can be established. The net cost to produce alcohol under Alternative A-3 is $0.87 per gallon

($0.47 plus loss of $0.40 tax credit). The ethanol could potentially be sold as a brandy at a profit of $6.73 per gallon, or as a wine fortifier at a profit of $1.98 to $2.93 per gallon. Assuming diesel fuel costs $1.50 per gallon, a gallon of ethanol sold as brandy could return 4.5 gallons of diesel fuel, or sold as a wine fortifier could return 1.3 to 2.0 gallons of diesel fuel at no cost to United Packing. This diesel fuel could be used in one of the power production alternatives described below.

ALTERNATIVE POWER PRODUCTION

Alternative ways of producing power at the Sanger facility were examined. They are identified as Alternatives C-1, C-2, C-3, and C-4. Alternatives C-2, C-3, and C-4 are true cogeneration schemes. In these alternatives, it has been assumed that 100,000 Btus per gallon of ethanol is required. This is in excess of the 72,000 Btus per gallon requirement shown above, but represents the only way the project can qualify under the Public Utility Regulatory Policies Act (PURPA) regulations. The regulations do not require efficient use of the steam, only that the overall efficiency guidelines are met. By this inefficient use of the steam, United Packing could possibly qualify as a cogenerator using fossil fuel under the PURPA regulations.

All of the following alternatives use diesel fossil fuel. The use of fossil fuels eliminate the technical issues associated with the use of alcohol fuels. Also, the cost of the fossil fuels could be offset by sale of the alcohol mentioned above.

Alternative C-1

This alternative uses three dual-fuel diesel engine generator sets, each rated at 750 kilowatts (kw). One unit would serve as a standby. This alternative would meet all the electrical demands of the plant year round. No heat recovery is included because at present there is no steam requirement at the plant, and therefore, this alternative would not qualify as cogeneration. It would not receive a special incentive rate for natural gas nor special priority for cogenerators (Priority 3A). In this case, the priority for gas would probably be Priority 3B, unless low-pressure gas standby facilities are provided. In that case, the priority would rise to 2B. In either case, we believe that the risk of interruption of the natural gas supply is greater than the risk of interruption of the utilities' electrical supply. For this reason, we believe the plant would be best served by fueling with natural gas as the primary fuel and maintaining a 1-month supply of No. 2 fuel oil (41,000 gallons) based on the maximum power consumption of 466,000 kwhr per month. For various reasons, the standby fuel supply should be turned over (by operating the equipment) at least once a year.

Since United Packing has a variable load and this alternative utilizes fuel oil, we have chosen the dual-fuel diesel engine as the prime mover. The gas turbine is technically feasible for the two fuels but has a poorer load-efficiency curve than the diesel. The spark ignition engine is capable of utilizing gaseous or highly volatile fuels. With this alternative, up to 13 million kwhr per year could be generated.

Alternative C-2

This alternative is identical to Alternative C-1 with the addition of waste heat recovery to produce steam. The facility could then qualify as a cogeneration system if at least 5 percent of the output of the facility provides useful thermal energy. This can be accomplished if ethanol is produced at the level of 60,888 gallons per year and the steam is used for feedstock preparation and ethanol distillation. The useful thermal energy is 12 percent of the output if we use 72,000 Btus per gallon for the alcohol production process. The steam demand of 72,000 Btus per gallon is the combination of 30,000 Btus per gallon for distillation and 42,000 Btus per gallon for feedstock preparation. However, the PURPA rules also require an overall thermal efficiency of 42.5 percent which can only be met by setting up the system to require a 100,000 Btu per gallon which is 45.1 percent efficiency. It is assumed that the same facility as in Alternative C-1 is built and generates 2.5 x 10^6 kwhr per year of electricity which is consumed by United Packing.

Alternative C-3

This alternative is identical to Alternative C-2 but would provide steam to produce alcohol from culls at Sanger plus culls from seven neighboring sheds (thereby increasing the production to 487,000 gallons of ethanol per year). To meet PURPA regulations, electrical production would have to be increased over plant demand.

Producing 487,000 gallons per year of alcohol at 100,000 Btus per gallon of steam would allow the annual production of about 25 x 10^6 kwhr per year and remain within the rules. However, when operating with two 750-kw generators, the maximum annual production is 13 x 10^6 kwhr per year with 2.5 x 10^6 kwhr per year used in-house and the remainder sold to PGandE at the current avoided cost without a capacity payment (0.603 per kwhr). The fuel is natural gas plus a 1-month supply of No. 2 fuel oil.

Alternative C-4

Alternative C-4 is identical to Alternative C-3 with the addition of one more engine generator. This will allow three engine generators to be operated continuously with one standby. This allows the annual production of 19.7 x 10^6 kwhr per year;

electricity in excess of plant demands is sold to PGandE. This alternative takes advantage of the rule that up to 25 x 10^6 kwhr per year can be produced under PURPA regulations.

Standby Power

This alternative is similar to Alternative 8 in Chapter 5, with the exception that the standby generators are fueled with diesel fuel. A 1-month supply should be provided.